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BEHAVIORAL ECOLOGY AND HABITAT RELATIONSHIPS OF LONG-BILLED CURLEW IN WESTERN IDAHO

USDI - BLM Research Contract

YA-512-CT7-54

by

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TABLE OF CONTENTS

	Page
Acknowledgements	i
List of Tables	ii
List of Figures	vi
List of Appendices	ix
Preface	x
Chapter I - Introduction	1
Objectives	2
Study Area	2
Methods	3
Chapter II - Breeding Biology, Behavior, and Ecology	11
Phenology Overview	11
Breeding Biology and Behavior	12
Sexual Dimorphism	12
Arrival and Pair Formation	12
The Undulating Flight Display	15
Nesting Behavior and Incubation	16
Nests and Eggs	18
Egg Size	23
Brood Movements and Home Ranges	26
Methods	26
Results	26
Discussion	41
Parental Care and Attendance	42
Mortality Factors	42
Methods	42
Eggs and Clutches	44
Chicks	46
Juveniles	53
Adults	53
Reproductive Success	54
Nests	54
Chicks	56
Population	60

TABLE OF CONTENTS (cont.)

	Page
Food Habits and Feeding Behavior	63
Methods	63
Results and Discussion	64
Chapter III - The Black Canyon Planning Unit (BCPU)	68
Vegetation	68
Methods	68
General Results	70
BCPU Plant Species Composition	70
Height of Vegetation on the BCPU	88
Vertical Coverage of Vegetation	89
Above Ground Productivity	89
Effects of Disturbance on BCPU Vegetation	89
Effects of Grazing on Curlews	91
Results	96
Discussion	100
Disturbance	102
Fire	103
Off-Road Vehicles (ORV's)	114
Transportation Network	120
Conversion of Rangeland to Human Residences	122
Agriculture	122
Associated Human Disturbance	126
Chapter IV - Long-billed Curlew Distribution, Abundance, and Habitat Use	128
Curlew Distribution	128
Methods	128
Results	128
Curlew Abundance	147
Methods	147
Results	147
Curlew Use Areas	147

TABLE OF CONTENTS (cont.)

	Page
Chapter V - Management of Long-billed Curlews on the BCPU	177
Literature Cited	186
Appendices	192

LIST OF TABLES

Table		Page
I-1	Numbers, age and sex of Long-billed Curlews banded during 1977, 78 and 79 on the BCPU	7
I-2	Numbers of adult and chick Long-billed Curlews radio-marked on the BCPU, 1977-79	9
II-1	Comparisons of weight, exposed culmen length, and tarsus length between female and male Long-billed Curlews on the BCPU, 1977-79	13
II-2	Distribution of 123 Long-billed Curlew nests according to aspect	19
II-3	Number of eggs per Long-billed Curlew nest, regardless of when nest first discovered	21
II-4	Long-billed Curlew egg dimensions and volumes	24
II-5	Long-billed Curlew clutch volumes	25
II-6	Daily movements of radio-marked Long-billed Curlew broods expressed as minimum total distances (MTD)	27
II-7	Weekly averages of daily movements by radio-marked Long-billed Curlew broods expressed as minimum total distances (MTD)	28
II-8	Daily movements of one Long-billed Curlew brood after termination of parental care and subsequent brood dissolution in 1978	31
II-9	Home range size of radio-marked Long-billed Curlew broods, 1977-79	33
II-10	Long-billed Curlew clutch losses	46
II-11	Individual egg losses from successful Long-billed Curlew nests	48
II-12	Mortality of radio-marked Long-billed Curlew chicks aged 0-5 days	51
II-13	Mortality of radio-marked Long-billed Curlew chicks regardless of age	52
II-14	Long-billed Curlew clutch survival	55
II-15	Estimated Long-billed Curlew nest productivity	57
II-16	Radio-marked Long-billed Curlew chick survival rates for pre-fledging period (0-45 days of age)	58

LIST OF TABLES (cont.)

Table		Page
II-17	Radio-marked Long-billed Curlew chick survival rates according to age class during pre-fledging period	59
II-18	Estimations of Long-billed Curlew reproductive parameters on the BCPU	62
II-19	Stomach contents of nine Long-billed Curlew chicks from the BCPU and two adults from northwest Colorado	67
III-1	Plant species occurring on the Black Canyon Planning Unit: 1977-1979	74
III-2	Alphabetic list of abbreviations used in the Tables and Figures for scientific names of plants	76
III-3	The top five ranking plant species in each of the 30 vegetation types in June 1977	78
III-4	The top five ranking plant species in each of the 30 vegetation types in each period of the curlew breeding season 1978	79
III-5	The top five ranking plant species in each of the 30 vegetation types in each period of the curlew breeding season 1979	83
III-6	Mean grams of vegetation biomass per 0.10 m^2 for each vegetation type 1978 and 1979	90
III-7	Size of treatment area, kind of use, number of livestock and AUMs on spring-fall sheep and cattle deferred-rotation treatment areas for each year 1977, 1978 and 1979	94
III-8	Size of treatment area, kind of use, number of cattle and AUMs on rest-rotation and common-use treatment areas for for each year 1977, 1978 and 1979	95
III-9	Number of hectares of vegetation less than 1 decimeter tall in treatment areas was significantly correlated with the number of curlews observed/kilometer censused, spring grazing intensity and spring stocking rates	101
III-10	Probable causes of 215 fires on the BCPU, 1955-1979	109
III-11	Changes in the importance values (IMPV) of the top dominant plants during 1979 on three burns which occurred in fall 1978	111
III-12	Approximate amount of land denuded by ORV use	119

LIST OF TABLES (cont.)

Table		Page
IV-1	Length of survey routes according to census block and year on the BCPU	130
IV-2	Mean numbers of male Long-billed Curlews seen per km per census survey during pre-laying through incubation and during brood-rearing in 1977-79	133
IV-3	Mean numbers of female Long-billed Curlews seen per km per census survey during pre-laying through incubation and during brood-rearing in 1977-79	134
IV-4	Numbers of male Long-billed Curlews seen per km per survey during pre-laying through incubation along the entire BCPU survey route and among years 1977-79	140
IV-5	Mean numbers of male Long-billed Curlews seen per km per survey during pre-laying through incubation on the BCPU, 1977-79	141
IV-6	Mean number of male Long-billed Curlews seen per km per survey in each census block; results of Duncan's Multiple Range Test	142
IV-7	Amount of non-suitable range in each of the nine census blocks on the BCPU	143
IV-8	Numbers of male Long-billed Curlews seen per suitable km per survey during pre-laying through incubation along the entire BCPU survey route and among years 1977-79	144
IV-9	Mean numbers of male Long-billed Curlews seen per suitable km per survey during pre-laying through incubation on the BCPU, 1977-79	145
IV-10	Mean number of male Long-billed Curlews seen per km of suitable habitat per survey in each census block	146
IV-11	Estimated mean number of male Long-billed Curlews attempting to breed per 100 ha of suitable upland on the BCPU, 1977-79	148
IV-12	Estimated number of male Long-billed Curlews attempting to breed in each census block on the BCPU, 1977-79	149
IV-13	Curlew numbers in the eight different "levels of use" on the BCPU	151
IV-14	Curlew density on each of the eight "levels of use"	153
IV-15	Percent similarity of plant species importance parameters for each "levels of use" area	155

LIST OF TABLES (cont.)

Table		Page
IV-16	The mean number of curlews seen and the mean heights of vegetation are negatively correlated during almost every time period	156
IV-17	The mean number of curlews seen and percent vertical average of vegetation are negatively correlated during almost every time period	158
IV-18	Ranges of percent vertical coverage measurements for the four types of vegetative homogeneity on the BCPU	159
IV-19	Total number and percent curlews observed per vegetation type from 1977 to 1979, number is based on census sorted data only	161
IV-20	Density of curlews in the 30 vegetation types correlates with number of curlews	162
IV-21	Mean vertical coverage and average number of curlews are negatively correlated during every phase of the breeding cycle except for the brood-rearing periods of 1978 and 79	163
IV-22	Mean vegetation height is negatively correlated with mean number of curlews in every phase of the breeding cycle except for brood-rearing periods 1978 and 1979	164
IV-23	Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to topography during almost all phases of the reproductive cycle 1979	170
IV-24	Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to height of vegetation during any phase of the reproductive cycle in 1979	173
IV-25	Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to vertical coverage of vegetation during any phase of the reproductive cycle in 1979 except for females during the brood-rearing period	175

LIST OF FIGURES

Figure		Page
I-1	General location of study areas in southwestern Idaho	4
I-2	Monthly precipitation recorded at Parma, Idaho from August, 1976 - July, 1979	5
I-3	Monthly mean daily temperatures recorded at Parma, Idaho from August, 1976 - July, 1979	6
II-1	Timing of Long-billed Curlew breeding events on the BCPU, 1977-79	14
II-2	Hatching dates for 135 Long-billed Curlew clutches, 1977-79 ...	22
II-3	Daily minimum movements of three young Long-billed Curlew broods	30
II-4	Daily minimum movements of a brood in which chick 243 was radio-marked (1979)	32
II-5	Two of the largest brood home ranges of radio-marked chicks in each of the three years, 1977-79	35
II-6	Parental attendance within Long-billed Curlew family groups compared over time and between years, 1977-79	43
II-7	A qualitative interpretation of Long-billed Curlew feeding strategies on the BCPU	65
III-1	Location of 30 vegetation types on the BCPU	69
III-2	Vertical coverage is evaluated from 3 dm above the ground in attempt to imitate the height of the curlew eye	71
III-3	Percent vertical coverage measures were obtained from 5 different distances from the randomly placed vision board ...	72
III-4	Location and extent of four kinds of vegetation on the BCPU ...	73
III-5	Location and extent of 17 grazing treatment areas on the BCPU during 1977-79	92
III-6	Sheep trail routes across the BCPU	93
III-7	Mean number of curlews observed per kilometer censused and mean vegetation height in sections of the BCPU were significantly negatively correlated during pre-laying and laying periods 1978 and 79	97
III-8	Mean number of curlews observed per kilometer censused and mean percent vertical coverage of vegetation were significantly negatively correlated during pre-laying and laying periods 1978 and 79	98

LIST OF FIGURES (cont.)

Figure		Page
III-9	Vegetation height ($\bar{x}$ and s.d.) for each period of the breeding season 1977-79	99
III-10	Number of hectares burned per section, 1955-79, by 5-year periods	104
III-11	Sections in which fall 1978 burns occurred in which re-vegetation studies were conducted during 1979: Lower and Upper Homestead burns, Little Freezeout burn	110
III-12	Height of vegetation on the three fall 1978 burns, during the 1979 growing season	112
III-13	Percent vertical cover on the three 1978 fall burns during the 1979 brood-rearing period	113
III-14	Sections in which fires occurred one or more times between 1955 and 1979 and numbers of curlews seen during 1977-79	115
III-15	Location of a private ORV enterprise and the three heavily used "ORV Parks" on BLM lands	116
III-16	Comparison of ORV use, 1977-79 in the different parts of the BCPU	118
III-17	Human residences and agricultural conversions on the BCPU are limited to the shaded areas	123
IV-1	Map of the standardized survey route on the BCPU	129
IV-2	Map of the 11 census blocks on the BCPU	131
IV-3	Spot-mapped territories in Little Freezeout census block during pre-laying through incubation, 1978	136
IV-4	Spot-mapped territories in Little Freezeout census block during pre-laying through incubation, 1979	138
IV-5	Distribution of the eight "levels of use" areas among the 30 vegetation types on the BCPU	152
IV-6	Mean vegetation height for each "levels of use" area on the BCPU for each period of the breeding season is different for each year and differs between kinds	157
IV-7	Relative steepness of the 110 sections of the BCPU	166

LIST OF FIGURES (cont.)

Figure		Page
IV-8	Relative steepness of the 110 sections of the BCPU expressed as number of meters horizontal distance between 6.1 meters contour intervals	167
IV-9	Long-billed Curlew males and females use different topographic features in similar ways	169
IV-10	Percent occurrence of curlews in vegetation by height category compared to availability, 1979	171
IV-11	Percent occurrence of curlews in relation to vertical coverage values compared to availability, 1979	174
V-1	Location and extent of public, private and state land on the BCPU	185

LIST OF APPENDICES

Table		Page
I-1	Precipitation at Parma, Idaho (in cm), August, 1976-July 1979	192
I-2	Mean daily temperatures (°C) recorded at Parma, Idaho for months: August, 1976 - July, 1979	193
I-3	Long-billed Curlews banded and color-marked on the BCPU 1977-79	194
II-1	Timing of Long-billed Curlew breeding events on the BCPU, 1977-79	202
II-2	Mineral contents of one Long-billed Curlew egg	203
II-3	Summary of data on 62 radio-marked curlew chicks on the BCPU, 1977-79	204
II-4	Long-billed Curlew nest failures, 1977-79	207
III-1	Vegetation heights on each of the 30 vegetation types, 1977-79	209
III-2	Percent vertical cover on the three 1978 fall burns during the 1979 curlew breeding season	212
IV-1	Tallies of male Long-billed Curlews seen along the survey route during pre-laying through incubation according to date and census block	213
IV-2	Mean vegetation height on each "level of use" area on the for each period of the breeding seasons: 1977-79	216
IV-3	Mean vertical coverage values for each "level of use" area on the BCPU taken from 5 distances	217
IV-4	Mean percent vertical coverage of vegetation measured from 5 distances from the vision board for each vegetation type on the BCPU	226

PREFACE

The Black Canyon Planning Unit is a low, rolling upland, lying between the Boise, Payette and Snake River Valleys west of Boise, Idaho. Most of the original sagebrush (Artemisia spp.)/bunchgrass vegetation was eliminated decades ago, and today consists primarily of shortgrass rangeland along with some agricultural development. Almost all of rangeland is owned by the federal government and is managed by the U.S. Department of Interior, Bureau of Land Management (BLM).

Until very recently, this public rangeland was managed almost exclusively for livestock grazing. By the early 1970's, BLM personnel and others began to recognize that an unusually large population of Long-billed Curlews (Numenius americanus) nested on portions of this short grass rangeland each spring. This public rangeland also serves as a breeding ground for Burrowing Owls (Speotyto cunicularia) and Ferruginous Hawks (Buteo regalis). All three species are classified as "sensitive" species by the BLM and Idaho Department of Fish and Game. It is BLM policy to ensure that the habitat of these species is conserved.

Because of its proximity to the rapidly expanding "Treasure Valley" communities of Boise, Nampa, and Caldwell, Idaho, the Black Canyon Planning Unit has become the focus of several opposing development interests. Within the last decade, the BLM has come under considerable pressure to release much of this public land to private development of agriculture (Carey and Desert Land Acts), residential communities, and recreational (off-road vehicle) use areas. Livestock operators whose livelihood directly depends on grazing rights to these public lands, understandably oppose such actions which would result in loss of rangeland. But additionally, these operators have exerted pressure on the BLM to improve grazing capacity of public rangelands (for instance by post-fire reseeding to crested wheatgrass (Agropyron cristatum)) and to permit increased stocking rates on their allotments. Finally, local and national conservation groups, recognizing that these rangelands might constitute an especially important breeding area for the relatively uncommon Long-billed Curlew, urged the BLM to assume its moral and legal responsibilities to manage wildlife resources (National Environmental Policy Act and BLM Organic Act), and in so doing to anticipate and resolve potential conflicts between competing development interests and the curlew population.

Because of these diverse pressures, the Boise District Office of the BLM has held land disposal actions and irreversable commitments of resources on the Black Canyon Planning Unit in abeyance until the effects of such actions on Long-billed Curlews could be predicted. This document represents, in part, our effort to provide the BLM with the data and analyses necessary to make these predictions and to manage Long-billed Curlews on the Black Canyon Planning Unit.

CHAPTER I

INTRODUCTION

This study of the behavioral ecology of Long-billed Curlews (Numenius americanus) on the Black Canyon Planning Unit was initiated by the Boise District Office of the BLM. Essentially no information was available in the literature on either the biology or the management of this species, and the BLM needed such information. With all the diverse pressures for changing the way the area was managed, the BLM needed to be able to predict how such changes would influence the curlews (see Preface).

Long-billed Curlews are large scolopacid shorebirds that historically nested on short-grass prairies across much of temperate western North America (Palmer 1967). While these prairies must represent one set of ecological conditions to which curlew behavior has adapted, understanding how this is so and how it came to be are different matters, particularly without adequate baseline data. Yet it is just these understandings which are necessary to develop sound management practices for curlews on the Black Canyon Planning Unit.

At the time this research was initiated, published accounts of Long-billed Curlew behavior and/or ecology were limited to a study of their vocalizations (Forsythe 1970), to a report on feeding behavior and diet from their winter range (Stenzel et al. 1976), and to assorted anecdotal notes dating back to the turn of this century (Silloway 1900; Wickersham 1902; Cameron 1907; Bent 1927; McLean 1928; Wolf 1931; Forsythe 1967, 1971, 1972, 1973; Tinken 1969; Graul 1971; Sadler and Maher 1976).

Since 1977 several investigations of Long-billed Curlew status, behavior, ecology, and habitat requirements have been completed from different parts of the species' breeding range (McCallum et al. 1977; Bicak 1977; King 1978; Allen 1980; and Pampush 1980). From these latter publications and these we have pieced together the following "hazy" picture of curlew behavioral ecology.

Long-billed Curlews arrive on the breeding grounds unpaired, and although they soon pair monogamously, several authors refer to apparently unpaired individuals and to groups persisting throughout the breeding season. There is general agreement that breeding birds are territorial, but some authors report that territories are dispersed while others state or imply that they are to some extent colonial. The possibility that their preferred nesting substrate is patchily distributed has not been considered as a possible explanation for their uneven distribution. Distraction displays, both aerial mobbing and "injury feigning" are widely reported. Clutch size is reported as usually four (rarely five or three) and incubation as about 28 days. Chicks are extremely precocial, and there are no reports of normal chick-adult interactions or ecology of the chicks except for minimum 6.5 km movement of one brood in 6 days in southern Canada (Sadler and Maher 1976).

Several students at the College of Idaho (Caldwell, ID) completed independent studies of Long-billed Curlews and of curlew-human interactions on the

Black Canyon Planning Unit. However limited, these projects were of great value in confirming the existence of a large breeding population of curlews and in identifying some problems inherent to studying these birds (Chase n.d.; Grimes et al. n.d.; Myhre n.d.; Nee 1972; Millington 1974; and Jorgensen 1975).

Why a behavioral ecology study? Behavioral ecology is a recently emerged field that attempts to blend aspects of traditional ethology with population ecology and the theory of natural selection. Its perspective is that 1) individual animals exploit environmental resources by behavioral means, 2) an animal's behavior is adapted to a certain set or sets of ecological conditions, and 3) an individual's performance of any given behavior will depend on immediate ecological conditions as well as on the behavior of conspecifics (or others) simultaneously interacting together (Davies and Krebs 1978). Whereas ethology has emphasized behavior of individuals and social behavior between individuals, behavioral ecology is directed more towards the social organization of individuals in a group or population and its adaptive significance.

OBJECTIVES

The primary objective of this research was to evaluate the effects of land cultivation, grazing, and human disturbance upon the reproductive performance, population dynamics, and social structure of the Long-billed Curlews on the Black Canyon Planning Unit. Specific objectives designed to help us achieve this goal include:

1) To inventory environmental parameters on the Black Canyon Planning Unit which include vegetation structure, physiognomy, differential management regimes, and various abiotic factors.

2) To measure the density and distribution of Long-billed Curlews along environmental gradients.

3) To study curlew breeding biology and ecology.

4) To assess the actual and potential competitive and predatory constraints on a population of Long-billed Curlews.

5) To detect if and how various environmental disturbance affect curlew behavior and behavioral sequences.

In addition, we did similar but much less intensive studies of curlew populations breeding on the Crane Creek and Kuna Planning Units. The results of these later studies are presented in a supplement to this report.

THE STUDY AREA

Intensive research was conducted on the western two-thirds of the Black Canyon Planning Unit from before Long-billed Curlews first arrived until after they departed in 1977, 78 and 79. In 1979 additional research was done on portions of the Kuna and Crane Creek Planning Units.

The Black Canyon Planning Unit study area (BCPU) is located in parts of Ada, Canyon, Gem, and Payette Counties northwest of Boise, Idaho (Fig. I-1). The area lies north of US 20, south of ID 52, west of ID 55, and east of US 95. Interstate I-84 crosses the western part of the BCPU. The Kuna study areas are southwest of Kuna in Ada County between the Union Pacific Railroad's Oregon Short Line, the Snake River Canyon and the Elmore County line. The Crane Creek study area is east of US 95 (from Payette to Indian Valley north of Midvale), west of ID 55, and north of ID 52 (including parts of Payette, Gem, Boise, Washington, and Adams Counties) (Fig. I-1).

The BCPU is characterized by hot, dry summers and cold, dry winters (Figs. I-2, I-3). Rainfall averages 27.36 cm per year at Parma on the southwest edge of the area (Fig. I-2). Most of the moisture falls during November through June. Vegetative growth is dependent on soil moisture, which depends on both winter snow and spring rain. The first field season (1977) was characterized by severe drought conditions, and the 1978 field season was extremely wet with very lush vegetative growth. The 1979 field season was much closer to the "normal" or long-term averages.

METHODS

We describe general methods below but certain specialized methods are described in later parts of this report when understanding the results depends on understanding the methodology.

A total of 312 curlews were captured and individually marked with one U.S.F.W.S. aluminum band and two colored plastic bands on one leg and three colored plastic bands on the other leg (Table I-1 and Appendix Table I-3). The bands are read from top down. Left and right always refers to the bird's left and right legs, regardless of the bird's position with respect to the observer. Although birds are banded most commonly around the tarsometatarsus just above the toes, we banded all curlews around the tibiotarsus. In this position the bands were more readily visible to us when the birds were walking than if they were placed lower down on the legs. Unfortunately bands in this position could not be seen when the birds were in flight. For the purposes of this study we felt it preferable to be able to identify curlews on the ground rather than in the air.

Adult curlews proved impossible to capture before they began nesting. Most adults were captured on the nest with a hand held drop net. The lead for each shelf of a standard Japanese mist net was extended approximately 6 m on each end with twine. The extended net was strung between two poles. Two workers held the poles horizontally being careful to keep the net taut and above the vegetation as they passed on opposite sides of a previously located nest. They then tried to lower the net over the incubating adult before it flushed, (approximately 40 captures including recaptures were made this way). A few curlews proved too wary for the drop technique. Six of these were captured on the nest with a radio-operated bow trap designed by Thomas Dunstan, but still some curlews refused to approach the nest when the bow trap was in place. At the other extreme, one female sat so tight that she was captured by hand.

We attempted to band curlew chicks on the day of hatching. They often dispersed as soon as their down dried, but they could sometimes be found in

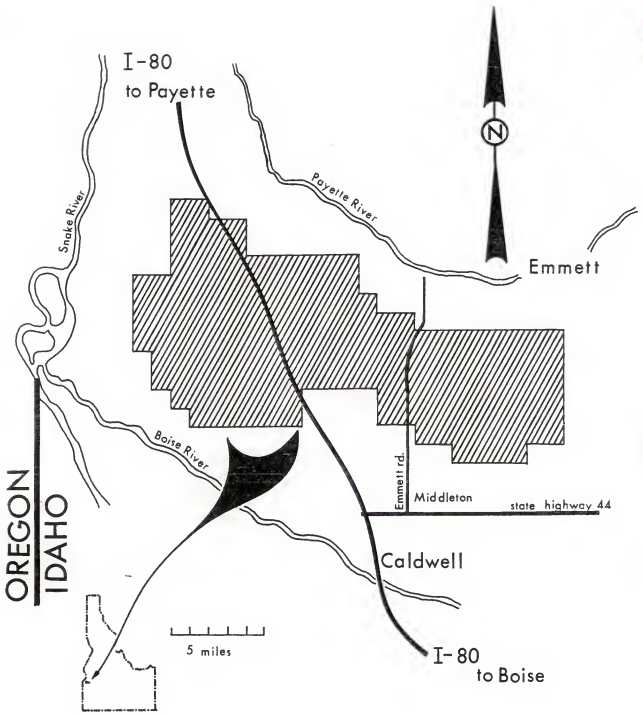


Fig. I-1: General location of study area in southwestern Idaho.

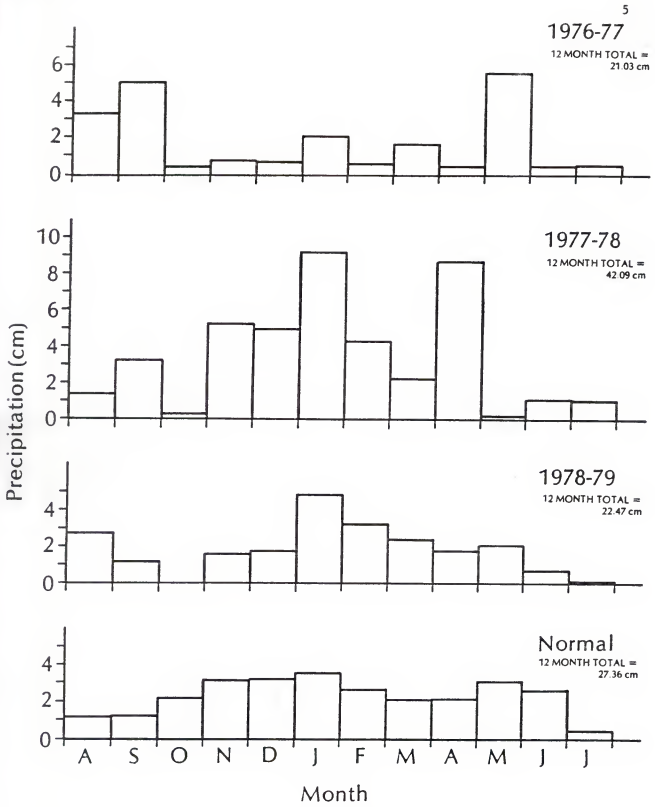


Fig. I-2: Monthly precipitation (in cm) recorded at Parma, Idaho, from August, 1976 - July, 1979.

See Appendix Table I-1.

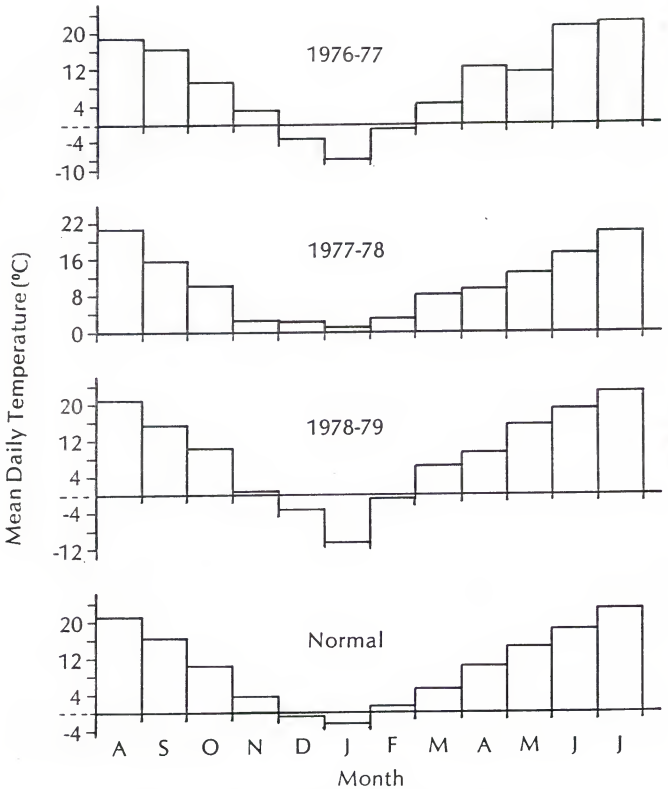


Fig. I-3: Monthly mean daily temperature (°C) recorded at Parma, Idaho, from August, 1976 - July, 1979.

See Appendix Table I-2.

Table I-1. The numbers, age, and sex of Long-billed Curlews banded during 1977, 78, and 79 on the Black Canyon Planning Unit.

	Number of Curlews Banded			
	Adults			
Year	males	females	Chicks/ juveniles	Total
1977	4	5	91	100
1978	4	12	82	98
1979	5	12	97	114
TOTAL	13	29	270	312

the general vicinity of their nest the day after hatching. Whenever we found an unmarked chick we searched systematically for others over an area of at least 300 m^2 in the vicinity. A relatively large number of chicks were found this way. We also located chicks for banding by watching adult behavior from a distance and then searching systematically through the area where we saw parental behavior or chick movements.

A few nests were found accidentally each year. One of us would come over a ridge, or be walking upwind and flush a bird from the nest. However, most nests were found by repeatedly and systematically searching areas frequented by curlew pairs. Because curlews sometimes sat tight on the nest until the searcher approached closely, the effective search width of a single trip through potential nesting areas was less than 5 to 6 m. Because of the great distances that needed to be covered, much of the searching was done on trail bikes and their use proved tremendously helpful. In 1978 and 79 several sheepherders reported the locations of nests they or their dogs discovered.

Nests were marked with a numbered wooden stake (2.5 x 5 x 40 cm surveyor stakes) with the top 10 cm painted red in 1977, chartreuse in 1978, and orange in 1979. The stakes were placed 10 paces directly uphill from the nest cup with one broad surface facing the nest. From then on we always approached the nest from the stake. We attempted to discourage mammalian predators from visiting these nests by placing a ring of paradichlorobenzine crystals around each nest.

Whenever captured, chicks and adults were weighed with either a triple beam or pesola scale and their linear measurements recorded. We used a ruler to measure the folded and flattened wing chord length and a vernier caliper to measure ex-posed culmen and tarsus lengths. Length and diameter of eggs also were measured with the calipers.

In all three years we radio-marked adult and chick curlews (Table I-2) and followed their daily movements by locating their signal and either triangulating their location or by moving in and making visual contact. It was necessary to recapture radio-marked chicks every few days to readjust their transmitter harnesses.

Hand-held yagi antennae were used routinely for radio-tracking. A null-peak antenna mounted on the rooftop of a four-wheel drive vehicle was used to locate birds that had moved so far as to be difficult to locate with the much shorter range hand-held antennae. When radio-marked curlews disappeared, we taped a yagi antenna to the wing strut of a small plane and flew regular search patterns over and around the BCPU.

Binoculars and spotting scopes were used routinely. Although most observations were made without the use of a blind, many observations were made through spotting scopes from vehicles parked at considerable distances from the birds. Blinds, both a woven wire, canvas covered barrel type and a sage-green back-pack tent were used to make detailed observations at selected sites. Although the incredible wariness, elaborate anti-predator behavior, and large territory size of the curlews limited the usefulness of blinds, they were essential for studying behavior on the nest.

Table I-2. Numbers of adult and chick Long-billed Curlews radio-marked on the BCPU, 1977-79.

	Number Radioed			
	Adults			
Year	males	females	Chicks/ juveniles	Total
1977	2	0	13	15
1978	2	3	13	18
1979	3	5	36	44
TOTAL	7	8	62	77

The social, anti-predator mobbing of curlews made it difficult to make undetected observations on the birds, except from blinds. However, we were concerned for the safety of observers in blinds which are extremely conspicuous. Most man made objects littering the BCPU were perforated by bullets, and a great deal of shooting of pistols, shotguns, and rifles occurred during all years on the BCPU.

Several curlews were shot in the Little Freezeout area by unknown persons in 1977. These events led to a closure of this area from 1 April to 1 August in 1978 and 79. Signs prohibiting vehicular access were posted around the perimeter of Little Freezeout during these time periods. This action helped reduce human use of the area and provided some protection from further shooting.

In all three years field research started when the curlews arrived on the BCPU and continued until they left the area in mid- to late summer. A few migrants might have passed through the area earlier or later in the season. The field research was conducted from March 21 to August 15, 1977, 1978 and 1979. Redmond started field work in March 1977; Bicak started in June 1977, and both of them worked through to completion of the project. One field assistant worked with Redmond in the spring of 1977 and two field assistants were employed for the 1979 season.

CHAPTER II

BREEDING BIOLOGY, BEHAVIOR AND ECOLOGY

PHENOLOGY OVERVIEW

Long-billed Curlews began to arrive on the BCPU during the fourth week of March each spring. They arrived in small flocks, and depending on weather and upland vegetative conditions, they did not always disperse immediately over the nesting habitat.

Nest-site fidelity was strong in many pairs, and individuals were likely to breed with their mates from the previous year. Courtship behaviors were much reduced between previously bonded pairs, although some behaviors suggest that re-establishment of the bond was necessary. The mating system was monogamous.

Unmated males established territories and performed conspicuous aerial displays soon after arrival. The frequency of aerial displays was reduced dramatically following mate acquisition. Unmated females arrived later than males, and their behavior was much less conspicuous.

Egg-laying occurred throughout April and as late as mid-May. We have no evidence of any renesting attempts by curlews on the BCPU. Clutch size was usually four. Incubation was shared by both sexes and lasted about 28 days. Hatching was synchronous within clutches, and weather permitting, chicks walked away from the nest several hours after hatching.

Parental care was shared initially between the sexes, but pair bonds weakened in June and many pairs abandoned their broods at this time. Some males continued parental behaviors and remained with their broods through fledging in mid-July.

Even though chicks were precocial and were not fed by adults, they relied on their parents for vigilance and warning of potential predators. In addition adults regularly brooded very young chicks at night and occasionally shaded them by day.

Brood movements were directed by the adults, but can appear random to observers. Some broods remained within the parent's original nesting territory while others wandered far and wide. Adoption of individual chicks into broods of similar age occurred infrequently.

Fledging began in mid-June and continued throughout July. By early July many juveniles gathered into flocks and moved into irrigated agricultural environments during mid-day hours when ambient temperatures often exceed 40°C. Flocking juveniles returned to upland habitats in the evening to feed on abundant grasshoppers and to roost.

Flocks grew in size as more chicks fledged, and numbers peaked about mid-July just prior to departure. Flock size diminished gradually suggesting that juveniles departed the BCPU in groups of 30-50 individuals. By mid-August of each year all Long-billed Curlews were gone from the BCPU.

BREEDING BIOLOGY AND BEHAVIOR

Sexual Dimorphism

Long-billed Curlews are sexually monomorphic in plumage characters, but females are larger than males and possess longer bills (Grinnell 1921). Such reversed size dimorphism is characteristic of all monogamous scolopacid shorebirds (Pitelka et al. 1974). We measured tarsus length, exposed culmen length, and weighed adult curlews on the BCPU all three years (Table II-1). Although there was more overlap in the measurements of tarsal length than in the other two parameters, the sexes had significantly different tarsal lengths ($p<0.0001$, $t=5.39$, 41df). There was no overlap between the sexes in culmen length which was the most reliable way of separating the sexes.

Females weighed more than males during every year of the study. However, in 1979 both females and males weighed significantly less than in the previous two years ($p = 0.03$, $t = 1.950$, 22 df for females; and $p = 0.04$, $t = 1.965$, 10 df for males). Because the lightest females in 1979 weighed less than the heaviest male in 1978 and the same as the heavites male in 1977, the pooled data for the three years show a slight overlap in weight. But we were not sampling smaller birds in 1979. Tarsal lengths in 1979 were not significantly different from the previous two years ($p = 0.63$, $t = 0.32$, 28 df for females; and $p = 0.18$, $t = 0.943$, 11 df for males). Nor were culmen lengths significantly different from the previous two years ($p = 0.18$, $t = 0.921$, 29 df for females; and $p = 0.34$, $t = 0.421$, 11 df for males). The lighter weight in 1979 coincides with unusually dense vegetation on the BCPU and the adult pattern of feeding on agricultural lands in 1979 (see page 15 and 23).

Arrival and Pair Formation

Long-billed Curlews predictably arrived on their breeding grounds in southwestern Idaho during the latter half of March. Curlews were first seen on the BCPU on 21, 19, and 20 March 1977-79. In all three seasons substantial numbers had returned by 1 April (Fig. II-1).

Curlews arrived on the BCPU in small, heterosexual flocks and dispersed quickly over suitable breeding habitat. Pairbonding began soon after arrival when females visited territories held by displaying males. It was possible that some individuals arrived with mates from previous years, but this was not confirmed from observations of color-marked birds.

Two of the four breeding pairs color-marked in 1978 paired again in 1979. In both cases the males were seen on their territories in the absence of females in late March. However, neither male was observed performing undulating flight displays, a characteristic behavior of unmated males (see below). This suggests that their female mates may have returned by late March even though we did not see them until 11 April. Other color-marked females associated with unmarked males (their mates were never captured and marked) and appeared to pair with them in the absence of courtship behavior as early as 23 March, 1978 and 26 March, 1979.

Males dispersed and were territorial soon after arrival in late March each year. Males without mates advertised their status by performing undulating flight displays (UFD's) and interacted aggressively with neighboring and with

Table II-1. Comparisons of weight, exposed culmen length, and tarsus length between female and male Long-billed Curlews on the BCPU, 1977-79.

Parameter / Year	Females				Males			
	Mean	S.D.	Range	n	Mean	Range	S.D.	n
Weight (g)								
1977	654	15.2	640-680	5	530.5	500-570	25.5	4
1978	654	26.2	623-698	7	555.5	507-597	32.5	4
1979	630	33.5	570-696	12	508.0	493-520	9.7	4
77-79	642	31.5	570-698	24	531.3	493-597	32.7	12
Culmen (mm)								
1977	172	12.8	159.0-196.0	6	129.9	125.0-138.0	5.0	4
1978	166	11.3	149.0-183.0	13	125.2	111.3-136.0	9.3	4
1979	164	10.9	141.8-181.0	12	125.5	115.6-136.0	7.5	5
77-79	166	12.0	141.8-196.0	31	126.8	111.3-138.0	8.05	13
Tarsus (mm)								
1977	85.6	1.44	83.8-87.0	5	80.5	79.2-84.0	2.14	4
1978	86.3	3.30	82.0-91.7	13	80.8	79.6-83.4	1.50	4
1979	86.7	3.11	80.2-93.0	12	82.0	76.9-84.3	2.69	5
77-79	86.4	3.07	80.2-93.0	30	81.2	76.9-84.3	2.39	13

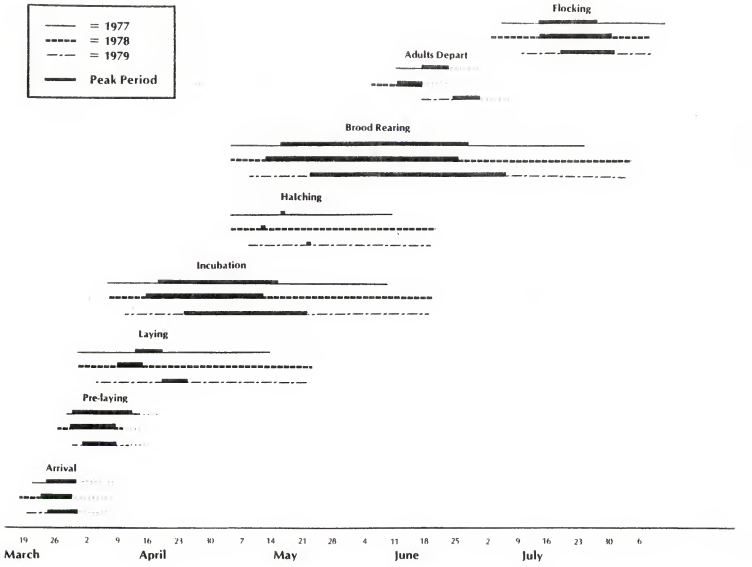


Fig. II-1: Timing of Long-billed Curlew breeding events on the BCPU, 1977-79. Termination of arrival, pre-laying, and adult departure are impossible to determine because they overlap with other activities from which they cannot be distinguished (see also Appendix II-1).

intruding males. They performed a variety of ritualized courtship displays when females entered their defended areas. When a female remained in such a territory, there was an impressive shift in the male's orientation. He concentrated his displays and aggressive behavior to the space around the female rather than around the periphery of his territory. This reduced attention to territorial boundaries in most cases was adequate to defend the area.

Some males ceased display over peripheral areas of upland breeding habitat after only a few days, whereas males with more centrally located territories continued to display and to court potential mates for 3-4 weeks. Whether these persistent males were attempting to pair for the first time or whether their mates had not returned was unknown. These observations do suggest that some females were available for mating in late April and hence may have arrived that late. Males stopped performing UFD's after establishing a pair bond.

In both 1977 and 1978 pairs generally remained together on their territories feeding and interacting. Both sexes actively defended feeding areas within their territories, and males usually defended greater portions of the territory than females. Males also frequently pursued territorial invaders (probably not neighbors) well beyond the limits of their territories.

In all years we observed territorial defense by bonded pairs to be sexually specific. Males interacted aggressively only with intruding males, and mated females drove off other females. Female-female aggressive interactions were much less frequent, however, than male-male interactions.

When curlews returned to the BCPU in March, 1979, vast tracts of residual, standing-dead vegetation (from the 1978 growing season) covered much of their upland breeding habitat. We suspect that this thick, dry cover interfered with the birds' ability to forage on the BCPU until grazing livestock gradually eliminated it. As a result, there was a dramatic increase in use of surrounding agricultural areas by the curlews for feeding. Birds fed in freshly plowed fields or wet pastures within 10 km on both the Boise and Payette River valley sides of the BCPU. There was no defense of these feeding sites; rather, locations changed frequently and attendance at any one site varied from about 5-80 adults feeding together in close proximity. Usually females outnumbered males in these flocks.

Breeding pairs spent much less time together on their territories throughout March-April, 1979. Early morning and evening hours were the only times we could predictably locate marked birds on their territories. Frequencies of aggressive interactions between curlews during this time period in 1979 were also much reduced due to the general lack of competition on the upland.

The Undulating Flight Display

The undulating flight display (UFD) was the most conspicuous display witnessed by us during the first part of the breeding season. It is an important display that simul-taneously communicates a male's availability for mating to females and his territorial boundaries to other males.

The UFD includes upward and downward components. The ascending male climbs silently and quite steeply (>45°) with rapid, shallow wingbeats for a

vertical distance of 10-15 m. The wings are then set with a downward curvature from the wrists such that both wingtips are held below the body plane. Simultaneously, the head is elevated slightly above the body plane on a partially extended neck. The legs and feet remain tucked within and along the body feathers. In this posture the male begins a low whistle call and glides downward at a more gradual angle (<45° but variable, depending on wind speed and direction in relation to direction of UFD). At a variable distance (3-15 m) above ground, the call stops and wingbeats resume. If the display is continued, the ascending portion is repeated immediately; otherwise the bird lands or proceeds with normal flight behavior.

UFD's varied in duration from a single cycle (approximately 30 sec.) to a very long series of undulations lasting up to 12 minutes. The intensity, duration, and route of a give UFD seemed to depend on the proximity of conspecifics, unattended females in particular, or on disturbance factors such as livestock, motor vehicles, humans, horseback riders, dogs, etc. The frequency of UFD's was greatest on calm mornings prior to 0900 hours in early April, but unmated males were apt to start UFD's anytime they were flushed.

Many other scolopacid shorebirds perform conspicuous aerial displays during the breeding season. In those species where males assume parental care responsibilities, display flights are performed only by males and tend to occur prior to mating with a female (Graul 1973; Hagar 1966; Hobson 1972; Holmes 1973; Jehl 1973; Lind 1961; and Miller 1979a). Most authors suggest that these displays function in the establishment and maintenance of territories and in mate attraction.

Within the genus Numenius, both the Whimbrel, N. phaeopus, and the European Curlew, N. arquata, perform similar display flights (Skeel 1976; Frisch 1956). Pre-mating display flights by male Long-billed Curlews or calls that might be associated with such a flight were not described by Forsythe (1970) but were by Allen (1980) who termed the display the Bounding - SSK Flight.

Nesting Behavior and Incubation

Males initiated nest-building with spontaneous acts of scraping behavior which lasted from 10-15 seconds to more than 30 minutes. Nest scraping began within a week of pair bond formation. At first females appeared to ignore a scraping male, and he would stop scraping after several minutes. Sometimes we saw a female standing nearby watching the male scrape. In these situations, his scraping bouts were longer in duration and appeared more intense. On two occasions we watched females participate in nest scraping. Both females exchanged places with their mate in the scrape, and began a similar series of chest twists into the depression followed by rapid backward kicking gestures. Neither female persisted in excavating the scrape. Instead, they soon stepped out to one side and began to pick up lining material and drop it into the scrape. Neither of these scrapes were further developed into active nests. It was common to find 4-6 scrapes at various stages of development within a single territory. Males often initiated precopulatory displays immediately after interactions with females around a scrape, but we never saw these displays lead to complete copulatory sequences.

Precopulatory vocalizations by males were audible over considerable

distance and alerted us to imminent copulation attempts. We heard these calls more often and witnessed most successful copulations in the late afternoon and early evening (1630-1930 hrs) during the first two weeks of April. At this time of day feeding tended to slow, winds often calmed, and disturbances were generally less frequent. Precopulatory vocalizations and attempted mounts occurred less often at other times of the day throughout April.

Female curlews apparently selected scrapes initially formed by males and begin to line them prior to egg laying. Curlews used two types of lining material in their nests, a basal layer of coarse-grained material such as small pebbles, strips of sagebrush bark, and/or sheep droppings, and above this a layer of grass. Some lining material was always present in nests when the first egg was laid. The lining process usually continued well into incubation and sometimes resulted in a well defined grass perimeter to the nest.

Observations at three nests during the egg laying period indicated that females spent little time at their nests prior to clutch completion. After laying their last egg, however, they remained on the nests and appeared to begin incubation. Males often attended these nests during the egg laying period in the females' absence. Even though these males sat on incomplete clutches for prolonged periods, we could not determine whether they were incubating. We also saw no evidence of camouflaging incomplete clutches with grasses, a behavior reported by Lind (1961) for Black-tailed Godwits (Limosa limosa).

Egg laying tended to occur in the middle of the day (1100-1500 hrs) and not always at daily intervals. A four egg clutch generally took 5-7 days to complete. It is difficult to be more precise with this figure because we never witnessed the laying of a first egg in any nest.

Once underway, incubation was shared between the sexes. Generally females incubated by day and males by night, but we noted many exceptions to this trend. On mild days in April and May nests were more often unattended than on stormy or very hot days.

Incubation postures also varied with ambient temperatures. We observed adults sitting tight over eggs less frequently on hot days. Instead many individuals alternated between bouts of loose sitting and shading of their eggs during the heat of the day. Also curlews erected the dorsal plumage on their heads and backs and panted vigorously while incubating nests at high ambient temperatures. Both these behaviors reduce abdominal air sac temperatures in related shorebirds (Grant 1979).

As incubation progressed, all males and most females became very active in nest defense. Both distraction displays and mobbing efforts became more frequent and intense once the eggs began to star (24-72 hrs. before hatching) simultaneously, duration of incubation bouts was reduced. Chick vocalizations became audible to human observers after the eggs had pipped (appearance of holes in the eggshells) and about 18-48 hrs before hatching. Both tactile and auditory stimuli from the eggs are probably involved in the release of the parental-aggressive behavior patterns (e.g. mobbing, sensu Simmons 1955) which becomes so evident at this time. Adults tending an infertile clutch (#99) in 1979 never exhibited mobbing behavior in spite of incubation at least 32 days.

Hatching synchrony within curlew clutches may be influenced by two sets of environmental factors: 1) prevailing weather conditions during egg laying and hatching, and 2) intensity and duration of disturbance at these time periods. Nests which hatched with greater within clutch synchrony (all 4 eggs hatch in a 4-6 hr. period) tended to do so during mild weather and/or in areas where disturbance was reduced. During adverse weather conditions, the hatching process was extended probably as a result of increased constancy of incubation by the adults (Norton 1972). Disturbance to the adults in cold and/or wet weather upsets incubation and may cause slightly more advanced embryos to hatch sooner and others to hatch later. In hot weather prolonged exposure of pipping eggs increases the chance of heat stress and death of the hatching embryos. Each year hatching occurred asynchronously at several nests, often at those which received heavy disturbance either by humans or local traffic. All three of the five egg clutches hatched so asynchronously that only first three young left each nest. Generally one adult continued to incubate unhatched eggs at these nests while its mate attended to one or more hatched chicks. The incubating adult, however, would not wait more than 8-12 hrs for later hatching eggs. Any disturbance during this critical period encourages an earlier abandonment by the adults.

Nests and Eggs

Curlews on the BCPU preferred nest sites located on west-by-southwest facing slopes. The mean aspect for 123 nest sites found during three years was 228.8° from true north (Table II-2). The distribution of these nest site aspects was significantly different from random for all three years combined ($p<0.001$). Preference for WSW aspect was disrupted in 1979 when vegetation was unusually dense.

Southwest aspects are generally the most xeric because evaporative power of the air tends to be greatest at mid day and early afternoon hours when incident solar radiation is directed at these slopes (Gaubenmire 1974).

We found 104 active Long-billed Curlew nests during the three years. Ninety nests (86.5%) contained four eggs (Table II-3). In both 1977 and 1978 we found single nests with only three eggs. We found one nest containing five eggs in 1978. However, in 1979, 11 of the 41 active nests found (26.8%) contained only three eggs. There was a highly significant difference in number of eggs per nest between the three years ($p=0.001$; Table II-3). Differences between numbers of three egg nests versus numbers of nests with more than three eggs in all three years were also highly significant ($p = 0.002$; Table II-3). Mean clutch size was significantly smaller in 1979 than in the preceding two years.

One unincubated curlew egg was collected in 1979 and stored frozen prior to analyses of its energy and nutrient contents (Appendix Table II-2). Dr. Stark performed these analyses in her laboratory at the School of Forestry, University of Montana.

The first curlew clutches hatched on 5 May 1977 and 1978, four days earlier than in 1979 (Figure II-2). However, the latest hatching dates were observed in 1978 and 1979, on 22 and 21 June. Hatching ended earlier in 1977, on June 11. In fact, the percent of chicks hatching in June increased over the three years of this study. Hatching, was substantially delayed in 1979 and this correlates with the apparent difficulty the adults experienced finding food and suitable nest sites early in the 1979 season.

Table II-2. Distribution of 123 Long-billed Curlew nests according to aspect.

Aspect[1]	Frequencies			
	1977	1978	1979	Total
15	1		1	2
20			1	1
30		1		1
40		1		1
45	2		1	3
50		5	4	9
60	1		3	4
70	1	1	1	3
75	1			1
80			3	3
90		2		2
100			2	2
110		1		1
130		1	1	2
135		1		1
140		1	3	4
150	1		1	2
160		1		1
170			1	1
190		1	3	4
200			3	3
210			2	2
215		1		1
220	1	1	2	4
230	2	1	4	7
235	1	1		2
240	3	5	1	9
245			1	1
250	6	3	4	13
255	1	2		3
260	2	4	1	7
270		1	4	5
280	2	3	1	6
285	1			1
290	2			2
300	1	1		2
310	1			1
315		1		1

Table II-2, continued.

Aspect[1]	Frequencies 1977	1978	1979	Total
320		1		1
330		1	1	2
340		1	1	2
TOTALS	30	43	50	123
$\overline{X}_{mag}$	264°	258°	200°	247.3°
$\overline{X}_{True}$	245.5°	239.5°	181.5°	228.8°
$\overline{R}^2$	0.525	0.266	0.179	0.2648
3	<0.001	0.05	>0.1	<0.001

[1] All measurements taken to nearest 5° interval from magnetic north. Magnetic declination at BCPU is 18.5° E.

[2] Mean aspect values from True N obtained by subtracting 18.5° from values for magnetic N ($\overline{X}$ mag) in above row.

[3] $\overline{R}$ statistic calculated according to Rayleigh test of uniformity, see Mardia (1972).

[4] Critical values of the Rayleigh test.

Table II-3. Number of eggs per Long-billed Curlew nest, regardless of when nest first discovered[1].

Year	No. of Nests	No. of Eggs/Nest 3	4	5	$\bar{x}$ No. Eggs	S.D.	Statistical[1]	Critical Value
1977	25	1	24	0	3.96	0.196	F-value = 7.37 (2;101 df)	= .001
1978	38	1	36	1	4.0	0.229	X^2 = 12.73 (2 df)	= 0.002
1979	41	11	30	0	3.73	0.443		
Totals	104	13	90	1	3.88	0.348		

[1] F-value calculated by one way ANOVA.
CHI-square 2 x 3 contingency table used to compare n = 3 eggs/nest vs. n > 3 eggs/nest for the three years.

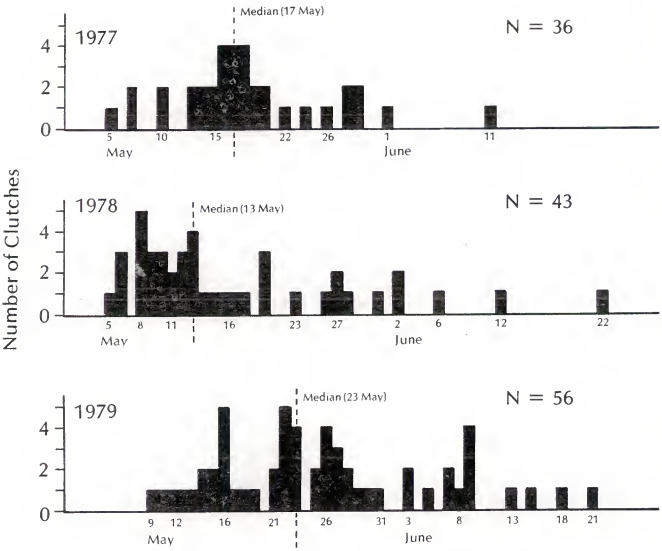


Fig. II-2: Hatching dates for 135 Long-billed Curlew clutches according to year. Included are: (1) observed hatching dates (N = 70); (2) estimated hatching dates from destroyed clutches where laying date of last egg was known (N = 18); and (3) estimated hatching dates for very young, unmarked broods (N = 47), see text.

Egg Size. We measured length (L) and maximum width (B) of 270 Long-billed Curlew eggs from 73 different clutches during 1977-1979. Egg volume (V) was calculated from these linear dimensions using the equation: $V = k_v \times L \times B^2$, and the volume coefficient for Long-billed Curlew eggs, $k_v = 0.476$ (Hoyt 1979). Egg volume is more biologically meaningful than length or width because it relates better to chick size at hatching. Furthermore, both linear measurements of the eggs are incorporated into the volume figures with less than 5% error (Hoyt 1979; Preston 1974). We used a nested analysis of variance design (Sokal and Rohlf 1969) to compare variability of volume among 260 eggs from 67 clutches, each containing 3 or more eggs, in 1977-79.

Egg size averaged 65.30 x 46.12 mm, and volume averaged 66.17 cm^3 (Table II-4). Length, width, and volume were smallest in 1979 (Table II-4). However, there was no significant difference in egg volumes among the three years ($P>0.05$). But there was a highly significant difference in egg volume among clutches laid by different females in each year ($P<0.001$). From the nested ANOVA, we estimate that 32% of the observed variance in egg volume was the result of differences within clutches. 66.3% resulted from differences among clutches within years, and only 1.7% was attributable to difference among years.

To account for the fewer number of eggs laid on the average by females in 1979 (Table II-3), we added the volumes of individual eggs within clutches to obtain total clutch volumes produced by females in each year. There was a significant difference in mean clutch volume among years ($P = 0.03$), and mean clutch volume in 1979 was about 7 cm^3 less than in 1977 and 1978 ($P = 0.05$) (Table II-5).

We found no evidence for a significant correlation between female curlew body size, as measured by tarsus length, and her average egg volume per clutch in any year ($P>0.05$ for each year). However, these correlations were positive in 1977 and 1978 ($r = +0.30$, $n = 11$, respectively) but negative in 1979 ($r = -0.41$, $n = 14$).

Egg size as measured by egg volume varied within a clutch laid by female curlews. Our sample size was too small to detect variability among years for the same females. Vaisanen et al. (1972) found annual variation among clutches laid by individual females to be significant for 4 shorebird species (Ringed Plovers, Charadrius hiaticula: Temminck's Stints, Calidris temminckii; Dunlins, Calidris alpina; and Red-necked Phalaropes, Phalaropus lobatus) but not so for a fifth species, the Redshank (Tringa totanus). For these five species the major component of variance in egg volume also was attributed to differences among females (Vaisanen et al. 1972). The fractions of variance in curlew egg volumes due to differences both among females and within clutches are within the range of values reported by Vaisanen et al. (1972) for these other shorebirds.

Data from several shorebird studies have shown a positive, but not always significant, correlation between egg size and female body size (Bowen 1976; Miller 1979; Vaisanen et al. 1972; and Vaisanen 1977). Negative correlations (not significant) between egg size and female body size were found only for Temminck's Stints and Red-necked Phalaropes (Vaisanen et al. 1972), both of which exhibit serial polyandry (Hilden and Vuolanto 1972; and Hilden 1975). With regard to Long-billed Curlews, we expected this correlation to be

Table II-4. Long-billed Curlew egg dimensions and volumes.

Year	Length (mm)		Width (mm)		Volume (cm^3)		N
	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	
1977	65.69 ± 3.07	59.9-72.3	46.23 ± 1.65	41.9-49.7	66.95 ± 6.30	50.56-81.83	87
1978	65.26 ± 2.72	59.3-71.7	46.41 ± 1.23	43.5-49.7	66.95 ± 4.67	55.84-78.36	77
1979	64.89 ± 2.40	58.6-69.8	45.82 ± 1.17	42.2-48.3	64.96 ± 4.27	52.87-73.06	106
Totals	65.30 ± 2.50	58.6-72.3	46.12 ± 1.38	41.9-49.7	66.17 ± 5.19	50.56-81.83	270

Table II-5. Long-billed Curlew clutch volumes.

Year	Mean Clutch Size	N	Average Total Clutch Volume (cm^3) $\pm$ SD	Statistic[a]	
1977	3.95	22	264.8 $\pm$ 29.0	$F_{(2,66)} = 3.554$	P = 0.03
1978	4.00	20	268.6 $\pm$ 31.4	$t_{(67)} = 2.637$[b]	P = 0.005
1979	3.81	27	247.2 $\pm$ 29.3		
Total	3.97	69	259.0 $\pm$ 30.9		

[a]P-value calculated by one-way Anova, t-value calculated by one-tailed t-test comparing mean clutch volumes from (1977 and 1978) with (1979).

[b]t-value remains significant (at p = 0.05) for a difference between these means of 7 cm^3.

positive as in 1977 and 1978. In 1979, larger females may have operated at a larger net negative energy balance after arrival on the BCPU due to greater absolute costs of foraging on surrounding agricultural lands. These females then laid less voluminous eggs than expected on the basis of their size.

BROOD MOVEMENTS AND HOME RANGES

Methods

We radio-marked one or more chicks in individual broods and then located these broods daily in the field. We did not always see the broods, but often relied on the radio signal (Appendix Table II-3). We estimated minimum total distance (MTD) per day by measuring linear distances between daily positions on maps of the study area. The actual distance walked by curlew broods was certainly much greater than the MTD's in most cases. Home ranges were mapped by connecting outlying location points to form convex polygons (Southwood 1966). The areas of these polygons were measured with a compensating polar planimeter and then corrected for variations in sample size according to the technique of Jennrich and Turner (1969).

Results

There was no clear pattern in the daily sequences of MTD's between different broods either within or between years. Movements were so variable on a day-to-day basis that the standard deviations approached mean MTD values in all three years (Table II-6). Because of these high deviations, it was not possible to detect statistically significant differences among these data, and this made the determination of biological significance more difficult. There was a significant positive correlation between mean weekly MTD's and age for 1-4 week old broods suggesting that distance traveled may be a function of age ($P < 0.02$, $r = +0.98$, $df = 2$, Table II-7). However, the increase in distance could be a response to some seasonal change in the environment or change in the chick's needs. Mean MTD's decreased slightly during the sixth and seventh weeks of age (Table II-7), even though many chicks became capable of flight at 35-40 days of age.

All curlew broods made both long and short distance moves. The differences in both the frequency and the timing of these moves were primarily responsible for the great variation in weekly average distances. However there appeared to be a general trend in all years. Upon hatching, a brood was likely to remain fairly close to its nest (within 100-300 m) for 1-5 days. At this age chicks were losing weight rapidly and they had to learn to feed effectively. The severe energetic constraints which they experience during the first few days must limit their ability to make long distance moves. After chicks began gaining weight (3-5 days of age), these energetic constraints probably eased; however, it was unusual to record MTD's of greater than 1 km prior to 10 days of age. Long distance moves usually entailed travel in excess of 1 km/day (MTD) for 1-3 days. With 2-3 day sequences, the net movement continued in a single direction and usually included a substantial reversal in direction. After such a long distance move, the brood typically remained within a relatively small area for several days and sometimes for several weeks before making another major move.

Table II-6: Daily movements of radio-marked Long-billed Curlew broods expressed as minimum total distances (MTD).

	Minimum total distance (m)			
Year	$\bar{x}$	Range	S.D.	N
1977	477	48-1670	337	143
1978	491	33-1730	404	76
1979	421	30-2220	357	188
Total	443	30-2220	359	407

Table II-7: Weekly averages of daily movements by radio-marked Long-billed Curlew broods expressed as minimum total distances (MTD), 1977-1979.

Age in Weeks	Minimum total distance (m) x	Range	S.D.	n	No. of broods
1	251	30-1340	252	53	12
2	379	32-1220	288	51	13
3	482	62-2220	398	52	14
4	527	59-1460	310	57	11
5	488	48-3220	502	66	15
6	429	48-1730	378	56	11
7	428	83-1630	310	41	8
8	723	83-1640	558	16	5
9	599	226-1600	369	14	2

Several examples illustrate the above tendencies. For age 1-10 days we recorded successive MTD's by a brood with radio-marked chick 78 of 155, 176, 119, 143, 523, 1030, 1340, 285, 201,a nd 229 meters. In this case (Fig. II-3) the first long movements occurred on days 6 and 7 post-hatching which was exceptionally early. The direction of these two long MTD's were exactly opposite; that is, this brood traveled approximately 1 km from its natal territory and then promptly returned. In this brood only one chick was radio-marked, the brood stayed together when they made their first long-distance move (Fig. II-3) between days 10 and 11. In 1978, chicks 157, 162 and 163 remained in their natal territory for days 1-10 post hatching (mean MTD for days 5-10 = 153 m, range = 95-298 m). On day 11 this brood disappeared for five days. We relocated them (with an aircraft) approximately 1.6 km away. These chicks did not make any especially long moves again until late in their fifth week just after both male and female parents disappeared and the family unit broke up. Their respective movements after break up are compared in Table II-8. Finally, locations of a brood in 1979 were monitored daily by movements of chick 243 through age 52 days. The shortest and longest MTD movements this brood made during each of its first three weeks were: 119 and 405, 131 and 620, 161 and 1040 meters (Fig. II-4).

Home ranges occupied by curlew broods varied greatly in size because size depended at least partly on the distances broods traveled. Mean home range area averaged 348, 464 and 176 ha for 1977-79, respectively. The differences in average home range size per year did not relate to mean number of locations per brood per year (22.4, 12.3 and 15.4). In 1979 our sample contained more chicks of younger age than in previous years, and this factor certainly contributed to the lower mean home range area in 1979. However there were real differences in chick behavior and in space utilization patterns among years.

There was a significant positive correlation between number of times we located a given brood in each year and its home range size in spite of the applied correlations for sample size bias (Jennrich and Turner 1969)($P < 0.005$, $r = +0.50$, 23 df for 1977-1979 combined). In 1979 correlation between number of observations and a given brood's home range size was highly significant ($P < 0.001$, $r = +0.96$, $df = 9$) but this correlation was not significant in other years (1977: $p > 0.20$, $r = +0.49$, $df = 5$; 1978: $p > 0.20$, $r = +0.52$, $df = 5$; 1977 and 78 combined: $p > 0.20$, $r = +0.43$, $df = 12$). The large difference between these correlations suggests that the broods were behaving differently in 1979 than in the previous years.

Home ranges based on maximum number of observations should be most relevant to a description of absolute brood requirements. We were able to follow one chick every day from its hatching on 22 May, 1979 through late July when it began wide-ranging flights around the BCPU and surrounding agriculture prior to its final departure about August 5. This chick (#243) occupied 849 ha, the largest home range observed in any year. The second largest range in 1979 was 501 ha (chick #303). The largest home ranges observed in the preceding years were 649 and 645 ha in 1978, and 622 and 610 ha in 1977 (Table II-9, Fig. II-5). These home range figures are underestimations of home range size because they are based on reduced numbers of observations.

It is possible to compare the home ranges occupied by broods of comparable ages. In 1977 chicks 80 and 93 were both followed until fledging (36 and 35 days of age respectively). Chick 80 occupied 408.7 ha and chick 93 used only

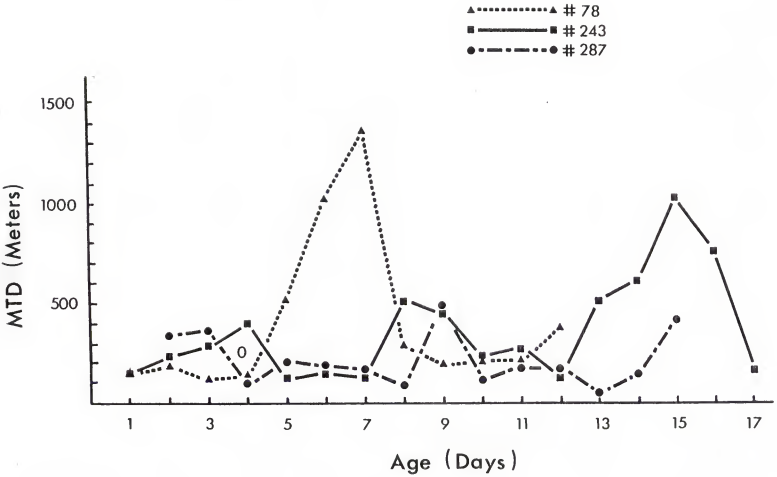


Fig. II-3: Daily minimum movements of three young broods shows a trend for broods to make relatively short moves for several days then to make considerably longer moves. It is also clear that the broods to not follow any rigid time schedule in the way they mix movements at varying distances.

Table II-8. Daily movements of Long-billed Curlew brood after termination of parental care and subsequent brood dissolution (1978).

Date	Age (days)	Minimum total distance of chick		
		#157	#162	#163
6/12	33	95	620	191
6/13	34	191	447	679
6/14	35	238	417	a
6/15	36	191	596	
6/16	37	179	477	
6/17	38	107	358	
6/18	39	179	429	
6/19	40	477	120	
6/20	41	358	179	
6/21	42	477	95	
6/22	43	238	727	
6/23	44	358	b	
6/24	45	441		
6/25	46	c		

a - Chick died from aspergillosus
b - Chick killed by raptor
c - Chick killed by Marsh Hawk

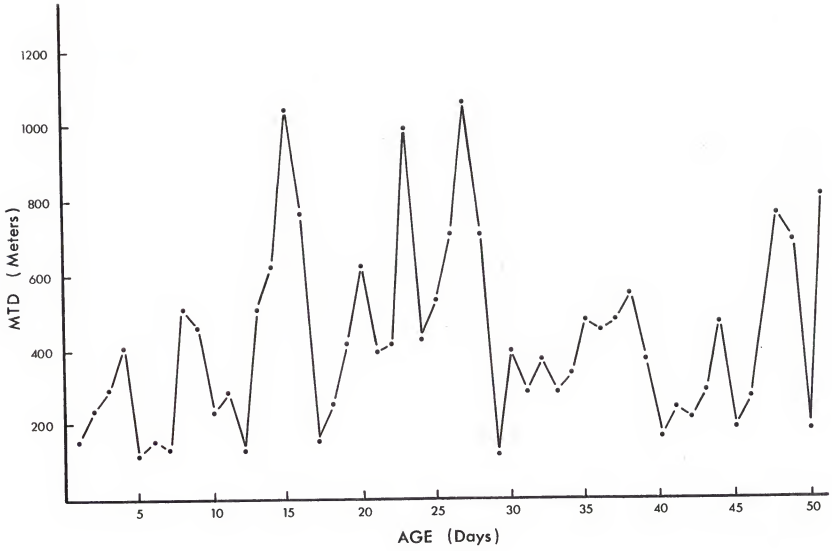


Fig. II-4: Daily minimum movements of a brood in which chick 243 was radio-marked (1979).

Table II-9. Home range size of radio-marked Long-billed Curlew broods. 1977-79.

	Brood	Home Range (ha)	No. of Locations	Age of brood
1977				
	48	610.0	22	35-64
	72	621.9	28	21-47
	75	187.8	10	10-17
	78	157.9	12	1-12
	80	408.7	31	1-36
	83	179.2	26	11-35
	93	269.7	28	5-35
1978				
	150	136.0	6	5-15
	157	424.6	17	5-44
	162	518.9	16	5-43
	163	245.5	10	5-34
	187	648.5	16	39-55
	194	645.1	11	28-38
	195	628.2	10	7-15
1979				
	220	51.5	8	1-8
	224	56.7	10	29-38
	235	21.9	4	1-4
	243	849.5	57	1-63
	257	349.1	22	32-45

Table II-9. Home range size of radio-marked Long-billed Curlew broods. 1977-79. (Cont.)

Brood	Home Range (ha)	No. of Locations	Age of brood
1979 (cont.)			
258	93.3	7	1-6
287	63.5	14	2-15
288	20.8	8	1-8
299	84.0	7	25-31
303	500.9	26	13-48
306	248.0	29	12-47

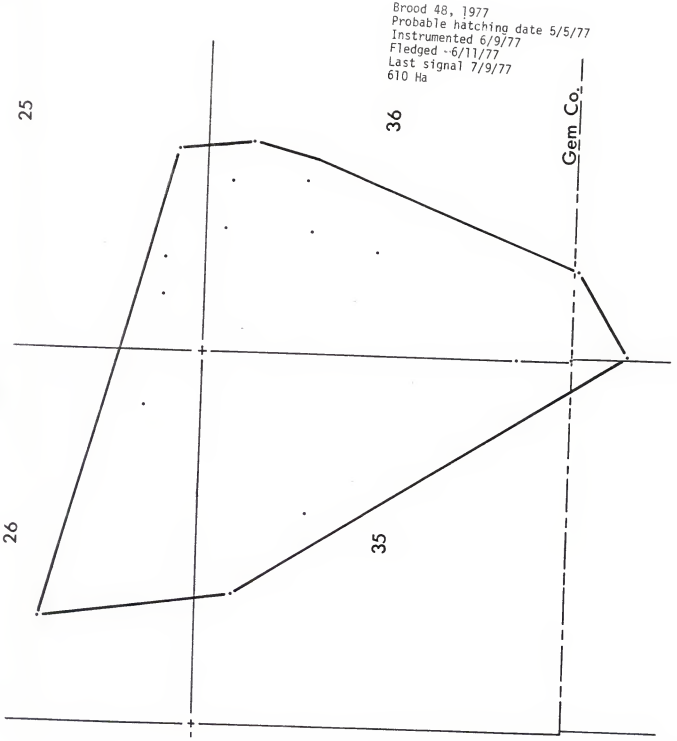
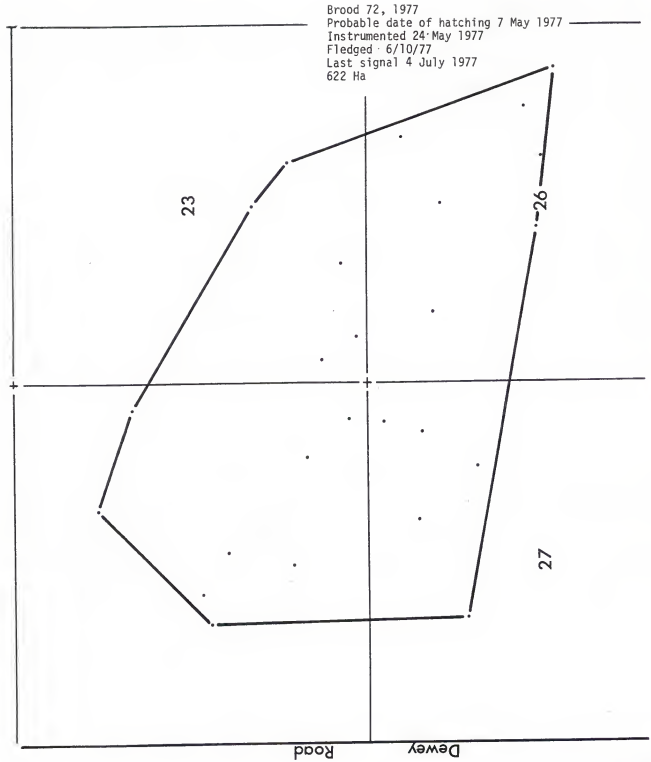


Fig. II-5: Two of the largest brood home ranges of radio-marked chicks in each of the three years 1977-79. Each location (only one for any single day) is shown as a dot and the outermost location are all connected. In some cases use was rather evenly distributed over the entire home range, in others use was concentrated in one or more localized areas.



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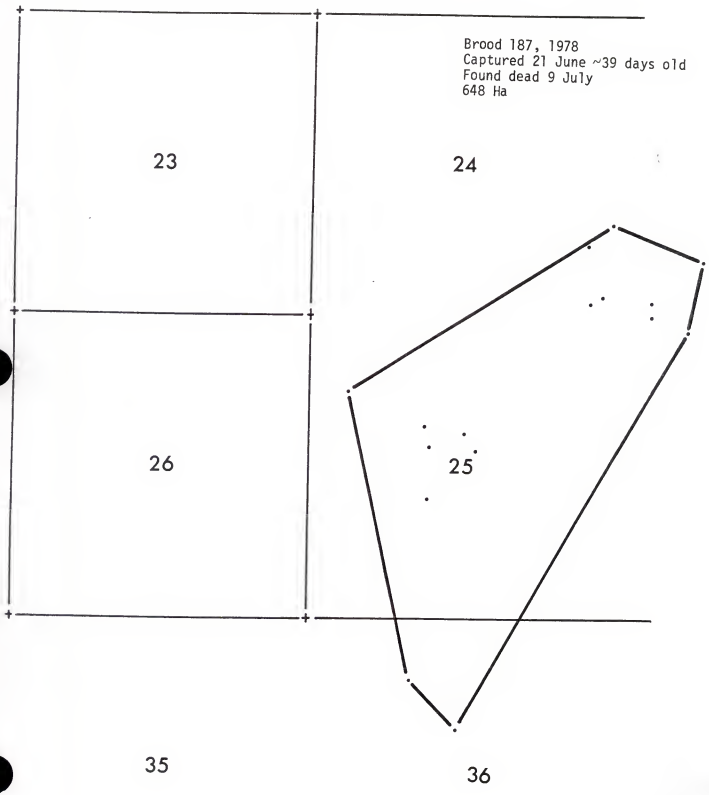

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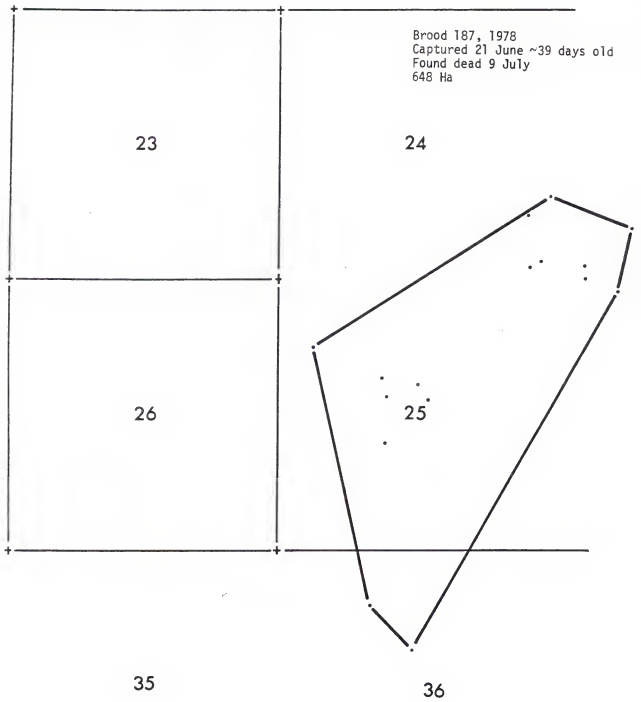

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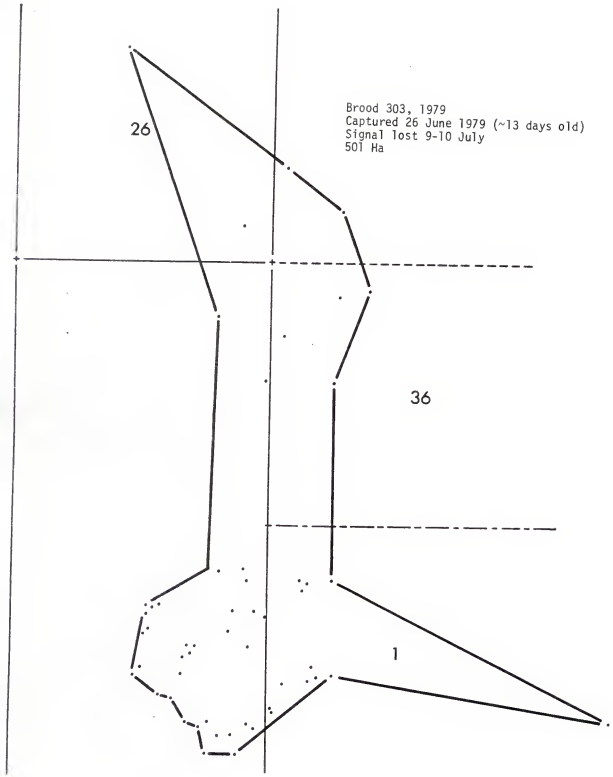

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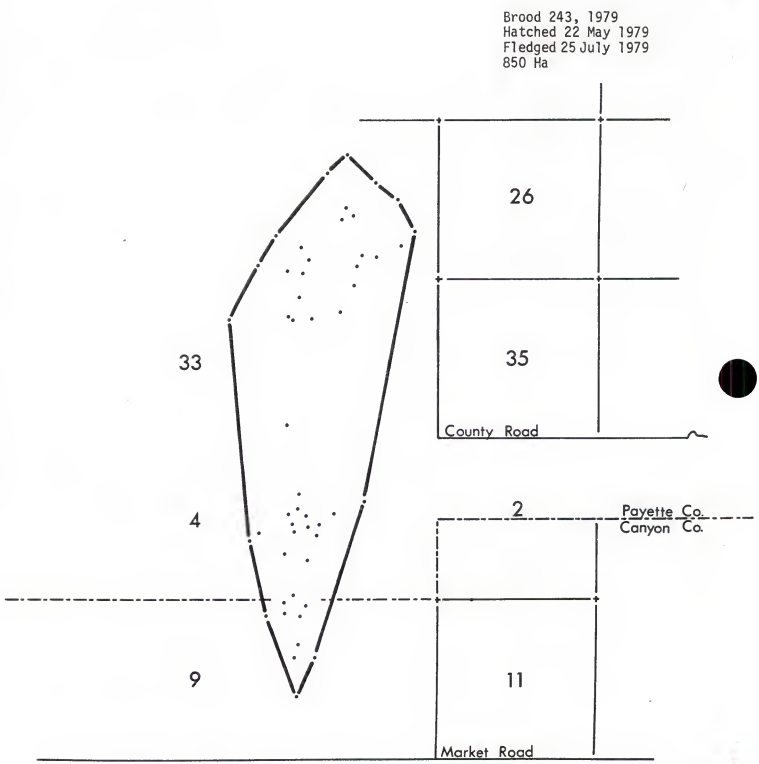


Fig. II-5: Continued.

269.7 ha. Both chicks hatched relatively late (5/28/77 for 80, 6/11/77 for 93), and each was attended by single males during the observation periods. The female parent of 80 was probably shot about 5/26/77. Chick 93 hatched near the edge of the BCPU, very close to the agricultural fringe, and did not make any very large moves. Chick 80 hatched in the upland and when it was 29 days old on June 27 it began a long move that ended when it came to the agricultural fringe area near chick 93.

In 1978 two broods containing chick nos. 150 and 195 both hatched in the same part of the Little Freezeout study area, chick 150 hatched May 7 whereas chick 195 hatched June 22. Both were followed until about 15 days of age but 150 occupied a home range of only 136.0 ha while 195 occupied 628.2 ha. This large difference suggests that habitat suitability and/or availability of food resources changed substantially in the 46 days between the hatching of the two broods. However, time of year did not always correlate with increased home range size. In 1977 brood 78 hatched on May 28 and occupied a home range of 157.9 ha during its first 12 days. In 1979 brood 287 hatched on June 9 and occupied only 63.5 ha during its first 15 days.

Discussion

Because of the significant positive correlation between number of observations and estimated home range size, it was necessary to adjust estimates based on small samples. In spite of these corrections there was still a significant positive correlation between number of observations and home range size. Clearly the correction factors presented by Jennrich and Turner (1949) are too small for curlew brood data, perhaps because their model is based on distribution qualities of either captures or observations in space which are not realized by the curlew broods. Specifically their model was not designed to include home ranges that include large movements between centers of activities. Can the concept of home range be applied to curlew broods?

Curlew broods tended to concentrate their movements within a small portion of their total home range for several days then make a move that was relatively large compared to the size of the home range they had been occupying. They then tended to stay in a relatively small area for several days, and it was not unusual for a different brood to move into their previously occupied area. Thus many areas were used sequentially over time by different broods. So even though it appeared that a brood occupied a series of home ranges whose total area was quite large not every brood needs its own exclusive 1000 ha.

How much space does a curlew brood require? Clearly this depends on habitat quality which varied greatly both among and within years and between different sites. Those broods for which data are most complete utilized minimum home ranges approaching 1000 ha. Most broods for which we have more than half the possible locations utilized close to 500 ha suggesting that they too had the potential to use home ranges reaching 1000 ha, or nearly four square miles. But considering the fact that several broods spent long, continuous periods in areas of about 250 ha or less, it is possible that 250 ha reflects minimum area needs of a curlew brood. But we rarely saw a brood restricted to such a small area. Not only do broods require more space than nesting adults but they use qualitatively different space.

PARENTAL CARE AND ATTENDANCE

Both parents tended early hatching broods for the first few weeks post-hatching. It appeared that both parents shared in all brood related behavior patterns. However, males appeared to take a more active role in mobbing potential predators, and females tended to lead the directional moves of young broods while the males tended to follow. However, we have too few observations of directional moves by young broods to be certain that this was a general trend. Female parents of late hatching broods stayed with the broods for much less time than female parents of earlier hatching broods.

Early in the brood-rearing season most broods were attended by both parents; but as the season progressed and increasing numbers of females abandoned their broods and the proportion attended only by males increased (Fig. II-6). Females tended broods in the absence of their male mate for the first time in 1979. This phenomenon was never common and probably is best explained as resulting from a temporary absence by some males (perhaps off feeding elsewhere) rather than by their abandonment in advance of females.

Females generally abandoned their broods before their mates and then remained on the BCPU for two or three days before disappearing. Males usually stayed with their chicks until they were ready to fledge. If his chicks were close to fleging when his mate was leaving, he might abandon with her. Occasionally a male stayed with his brood until the young fledged late in July and joined the pre-migratory, mid-summer flocks. We do not know whether these males stayed on with their fledged broods, or even whether these broods stayed together within the flocks. Some broods, especially those abandoned by both parents, split up long before joining mid-summer flocks.

MORTALITY FACTORS

Methods

Vulnerability of Long-billed Curlews to predators on the BCPU related to many factors. To facilitate discussion of this complex topic, we considered curlew vulnerability separately for four age classes: (1) eggs/clutches, (2) chicks, (3) fledglings/juveniles, and (4) adults.

The diversity of potential predators on and around the BCPU made it difficult to interpret every act of predation or clutch loss and to identify responsible species. Mammalian carnivores that hunted regularly over portions of the BCPU included: coyotes (Canis latrans), feral dogs (C. familiaris), feral cats (Felis domesticus), badgers (Taxidea taxus), and long-tailed weasels (Mustela frenata). Red fox (Vulpes fulva), striped skunk (Mephitis mephitis) and raccoons (Procyon lotor) were never seen hunting in upland habitats, but were sighted periodically along roads in the adjacent agricultural areas.

We attributed a nest loss to a badger if the nest cup was damaged and buried under several centimeters of soil. Large, crushed shell fragments often lay beneath this soil or in the immediate vicinity of the destroyed nest. Canids were presumed to be responsible for an empty, undamaged nest cup

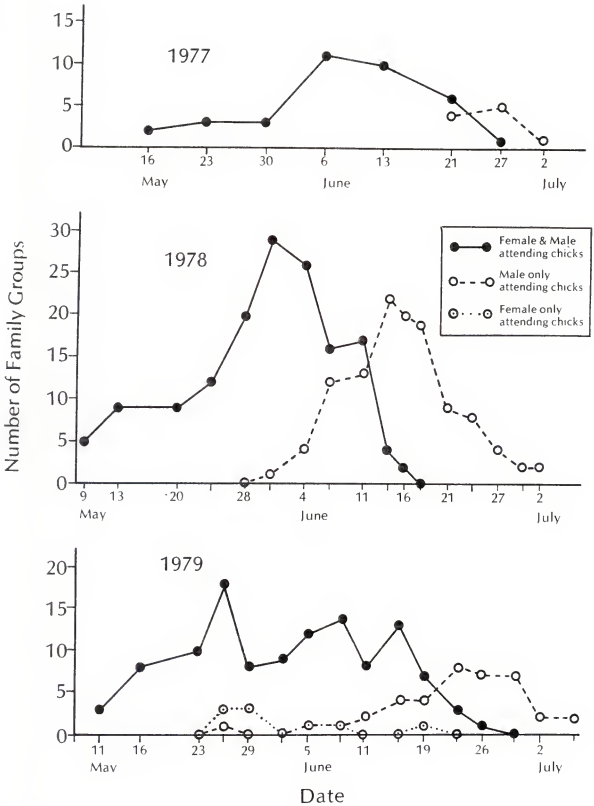


Fig. II-6: Parental attendance within curlew family groups compared over time and between years 1977-79.

whenever the previous visit had revealed an intact clutch. We assume that canids consume entire clutches and ingest whole eggs, leaving little evidence in or about the nest cup. In some cases we found intermediate conditions where the nest cup was damaged but not buried, and where several large shell fragments were lying around. Usually these shell fragments appeared unstained and licked clean on their inner surfaces. Such losses were suggestive of raccoon predation (Anderson 1969) but were attributed to unknown mammals.

Avain predators usually did not destroy an entire clutch; instead, they would peck into and consume portions of one or two eggs. Such nests were abandoned by adult curlews and any remaining eggs were subsequently consumed. Black-billed Magpies (Pica pica) were the only common avian egg predators on the BCPU, although Common Ravens (Corvus corax) occasionally passed over the area during April and were mobbed vigorously by adult curlews. Several gull species (California Gulls, Larus californicus; Ring-billed Gulls, Larus delawarensis; and Franklin's Gulls, Larus pipixcan) also used portions of the BCPU periodically, particularly areas surrounding plowed agricultural lands in early spring, and the environs of the Gem County Sanitary Landfill Site (Dewey Dump). We rarely saw aggressive interactions between adult curlews and gulls, but we do not doubt the response of these omnivorous birds to unattended eggs or chicks. Finally, there were several instances of entire curlew clutches destroyed but not consumed by a bird. In each of these clutches, all four eggs were pecked into but it appeared that no attempt was made to extract the contents.

Grazing livestock also destroyed curlew nests. Characteristically one or more eggs disappeared coincident with the presence of sheep or cattle in the vicinity of the nest. Sometimes a crushed egg remained in the cup or an egg was dislodged some distance.

Gopher snakes (Pituophis melanoleucus) were the only reptiles found on the BCPU that were capable of preying on curlew eggs or chicks. We encountered these snakes regularly during late spring, but the individuals were always of relatively small size and unable to swallow a curlew egg whole. The existence of individual snakes large enough to ingest whole curlew eggs is documented (Tremaine 1975), but we doubt that such predation is frequent on the BCPU. All our records of single egg disappearance from curlew nests are more logically attributed to other factors.

We have no evidence of direct human destruction of curlew nests either wanton or inadvertant, but the potential for such losses is real, particularly in high-use recreation areas. For example, in 1978 we measured off-road vehicle tracks within twenty cm of an active nest cup (no. 59) just south of the county road through the Sand Hollow study area.

Eggs and Clutches

Long-billed Curlews lay their eggs in open nest cups on the ground surface. The olive-green shells are mottled with brown and are highly cryptic. Certain eggshell pigments probably function in solar energy reflection (see Bakken et al. 1978), and the relatively large size facilitates thermal storage (see Frost and Siegfried 1977). Cryptic color, solar reflectance, and thermal storage are all adaptations for ground-nesting on short-grass prairies. The large size of curlew eggs precludes consumption by many smaller egg predators,

but it also makes them rewarding and hence attractive to predators capable of eating them.

Mammalian carnivores were the most important curlew egg predators on the BCPU in all three years. Of the 50 curlew clutches destroyed, 36 (72%) were taken by mammals (Table II-10). Black-billed Magpies fed on eight (16%), and livestock caused at least five abandonments (10%). Even though mammalian carnivores had the greatest impact on curlew nesting success every year, the relative importance of the different mammals varied. In 1977 badgers destroyed 7 clutches and canids destroyed 3, but in the next two years badgers destroyed 3 clutches each year and canids destroyed 7 and 10.

Canids were the most important curlew egg predators over the entire BCPU. However, in areas of high Townsend ground squirrel (Citellus townsendii) density, badgers were more destructive of curlew eggs. In 1977 we worked intensively west of Interstate 84, and 67% (20/30) of the nests were found in the Sand Hollow study area where badgers were quite numerous. In 1978 and 79 only 17% (15/88) of all nests were found in this area. Nests sampled during 1978 and 79 were from several different parts of the BCPU, and therefore were more representative of conditions over the entire BCPU (see Appendix II-4 for complete descriptions of individual clutch losses).

It was difficult to identify any specific canid as the most important egg predator. Coyotes were seen infrequently on the BCPU and red fox were known to inhabit adjacent agricultural areas within 3 kilometers of curlew nesting habitat. Dogs were by far the most abundant canid. Sheepherder's dogs were generally well-trained, and their potential impact on the curlews appeared to be slight. The same cannot be said for other dogs that frequented the BCPU from April-June each year. Unattended dogs often roamed across areas near human developments. People visiting the BCPU for recreation often brought dogs that ran widely across the uplands, and unwanted dogs occasionally were abandoned along roads through the Planning Unit. Wild dogs were an obvious problem in 1979. On four separate occasions between April and July, 1979, we encountered at least two different packs of 3-4 individuals running wild in Little Freeze-out. In April a local rancher used trained wolfhounds to help him hunt dogs that were killing livestock on the BCPU, and in May we found one active breeding den near Dewey Dump.

Grazing livestock caused a minimum of five nest desertions by Long-billed Curlews in 1978 and 79 combined. Sheep were responsible for four of these and cattle for one. Chance played an important role in nest survival when large sheep bands moved through areas of curlew nests. On two separate occasions in 1977 we watched bands of more than 500 ewes and lambs trample past the same two neighboring nests (Nos. 9 and 10) en route to a water trough. Neither clutch was damaged but each time one of the wooden marking stakes 10 m. from the nest cups was snapped off and crushed. Soon after both of these passings, the adult curlews returned to resume incubation. In 1978 and 1979, similar, but less dramatic interactions resulted in several broken eggs and four nest desertions.

Breeding pairs varied in their tolerance of sheep and cattle disturbance. Important factors influencing any tolerance threshold included: length of incubation prior to the time of disturbance or partial destruction; extent of egg(s) destruction; duration, frequency, and proximity of disturbances; and

Table II-10. Long-billed Curlew clutch losses.[a]

Year	N	No. of Clutches Destroyed Occording to Class: Canid (%)	Badger (%)	Other Mammal (%)	Avian (%)[b]	Livestock (%)[c]	? (%)	Total Destroyed (%)
1977	30	3 (10)	7 (23)	-	2 (7)	-	-	12 (40.0)
1978	40	7 (18)	3 (7.5)	1 (2.5)	2 (5)	3 (7.5)	-	16 (40.0)
1979	48	10 (21)	3 (6)	2 (4)	4 (8)	2 (4)	1 (2)	22 (45.8)
Totals	118	20 (17)	13 (11)	3 (3)	8 (7)	5 (4)	1	50 (42.4)

[a] See Appendix Table II-4 for listings of individual clutch losses.

[b] In most cases, nest desertion by adults was suspected prior to loss of eggs to magpies; see text for discussion.

[c] Cattle responsible for only one clutch loss (1979), others in column attributed to sheep.

any association of the disturbance with sheepherders, ranchers, or other intruding humans. Adult curlews were seen removing single slightly damaged eggs from two nests in 1979 (Nos. 103, 111). At one nest (No. 33), two eggs disappeared several days apart and coincidental to the passage of sheep bands. One of the eggs vanished just before the clutch was completed and the other just after, but the adults did not abandon. However, sheep moved back into the area, a third egg vanished, and the fourth was damaged and displaced about a meter from the nest cup; then the adults disappeared. Incubation was well along (>10 days) at nest No. 39 when we found one egg completely crushed in the cup. Sheep were feeding close by. Although the three other eggs were undamaged, the adults were never seen again at this site.

It is difficult to understand clutch losses to avian predators because adult curlews can protect their eggs from individual magpies, ravens, or gulls. Black-billed Magpies were abundant along the upland interface with agricultural land, and in early to midsummer these corvids invaded the uplands in large foraging flocks. However, we did not observe such flocks during April or May. It is unlikely that breeding curlews had to contend with the simultaneous intrusion of more than one or two magpies at their nests.

We suspect that the high incidence of clutch losses to avian predators shown in Table II-10 is deceptive and that magpies gained access to these clutches only as a result of parental nest desertion or abnormal inattendance. Both clutches destroyed by avian predators in 1978 were thought to be previously deserted, one because of human disturbance associated with repeated ORV use along the nest ridge (No. 59), and the other because of extended sheep disturbance (No. 43). Three nests probably were predated during prolonged periods of nest inattendance which sometimes followed trapping and handling of an adult (Nos. 30, 105, 116). This was more of a problem in 1979 when a nesting bird's mate was less likely to be present on their territory, and hence able to take over incubation after our trapping effort.

Two unusual cases of egg damage were recorded (nos. 24, 101). All eggs in both clutches were pecked into, but there was no evidence of feeding on their contents. The holes, approximately 15-30 mm in diameter, were considerably smaller than those made by magpies. Both of these nests, No. 24 in particular, were close to other active curlew nests (within 40 m).

Individual egg losses from otherwise successfully hatching nests were recorded each year. These losses were generally a result of: 1) infertile or addled eggs in a clutch (n=6); 2) parental abandonment of late, asynchronously hatching eggs (n=5); and 3) grazing livestock (n=5) (Table II-11). In 1979 our increased trapping efforts resulted in fatal damage to four eggs (attributed to "Other" factors in Table II-11). Assuming that these four eggs would have hatched in the absence of our disturbance, the percent of eggs not hatching in 1979 was 6.7% (6/90) and comparable with the 1977 value. Increased losses in 1978 were due to higher incidences of addled or infertile eggs as well as damage by livestock.

Chicks

Long-billed Curlew chicks were precocial and were never fed by their parents. Nevertheless, parental care was relevant and important; curlew chicks relied completely on adults (parents and/or others) for detection of

Table II-11. Individual egg losses from successful long-billed curlew nests.

Year	Successful Nests	Eggs Known to Hatch	Eggs Not Hatching	(%)	Loss Attributed to:			
					Infertile/ Addled	Abandoned	Livestock	Other
1977	18	61	4	(6.6)	1	3	-	-
1978	24	85	8	(8.6)	3	1	3	1
1979	26	80	10[a]	(11)	2	1	2	5[a]
Totals	68	226	22	(8.9)	6	5	5	6

[a] Four of these eggs incurred fatal damage as a result of trapping efforts by investigators. Assuming that these eggs would have hatched, 6/90 eggs from successful nests, or 6.7%, probably failed to hatch in 1979.

predators. All chicks responded to adult alarm calls by crouching and freezing in the vegetative cover. This behavior by the chicks, coupled with their cryptic, down plumage, minimized their vulnerability to visually hunting predators. In addition, young chicks were brooded during cold or wet weather, and they were shaded by adults on hot, sunny days.

In many precocial species, mortality of chicks between hatching and learning to feed is very high (Hilden 1978; Holmes 1966; Jehl 1973; and Soikkeli 1967). For Long-billed Curlews in this age class (0-5 days), mortality was most often the result of genetic factors, starvation, and/or predation.

Each year we found several curlew chicks in or near their nest cup that had not survived more than a few hours (n=3, 2, 2, 1977-79, exclusive of radio-marked individuals). The three non-viable hatchlings (No. 28, 37, 100) in 1977 were from different 4-egg clutches. Their hatching weights were 20-25% below those of their respective sibs. All three had poorly healed umbilical regions and incomplete yolk sac retention, perhaps due to the adherence of singular, small pieces of dried shell and/or membranes to the yolk sac. There was nothing peculiar about the appearance of non-viable hatchlings in 1978 or 1979. Chick No. 141 was from the 5-egg clutch in 1978. It hatched and died the morning after three viable sibs had hatched and departed the nest. We suspect the parents had abandoned the two remaining eggs (one rotton) the previous evening, and that chick No. 141 became severely chilled during the ensuing cold and rainy night. Chick No. 239 hatched on a very hot day in 1979 and never left its nest cup (No. 95). It is quite likely that disturbance to the attending adult interfered with incubation or shading and caused overheating of this chick, as well as two pipping embryos which never hatched. We were unable to determine causes of death for chicks No. 173 and No. 246 (in 1978 and 79).

Incomplete yolk sac retention and a poorly healed umbilical cord are signs of insufficient or prolonged warming of eggs during incubation for domestic chicks; whereas, adherence of chick embryos to portions of the eggshell occur under conditions of insufficient humidity (Rol'nik 1968). Five percent (3/57) of the curlew nestlings handled during 1977 showed the above characteristics and as a result were inviable. There was no evidence of similar inviability from 118 nestlings handled during 1978 and 1979.

The drought conditions of 1977 undoubtedly could have reduced humidities in curlew nests, which in some cases may have resulted in an increased net loss of egg water (see Walsberg 1980; and Ar and Rahn 1980). The response of curlew embryos to dehydration is not known, but we speculate that yolk sac adherence to the outer membranes and eggshell proper may have been one result of excessive embryonic water loss. This adherence could then prevent proper retention of the yolk sac and healing of the umbilicus at hatching.

Because of their cryptic plumage and behavior, it was very difficult to locate curlew chicks once they left their nests. Therefore, we relied on fates of radio-marked chicks for detection and rates of mortality. In 1979 our sample size of radio-marked chicks doubled, and we focused efforts on much younger chicks (average age when radioed decreased from 15.8, to 14.0, to 6.0 days for 1977-79, respectively). We detected no mortality of very young radio-marked chicks in 1977 or 78 because of small sample sizes. But in 1979

mortality within this egg class (0-5 days) reached 57% (12/21) (Table II-12). Many of these chicks (29%) seemed to be only marginally viable because they died within hours of hatching and quite near to their nests. Two other died on their fourth and fifth day, respectively, after never gaining weight or showing signs of feeding. We inferred that both starved. Two siblings may have perished as a result of heat stress on their fourth day. They hatched on 18 June, 1979, near the County Rd. west of Sand Hollow. The female parent disappeared the day after hatching leaving the male to provide all parental care. The family crossed the County Rd. on 20 June and entered a sparse crested-wheat grass planting where grasshoppers were abundant, but where shade was scarce. Excessive traffic along this road on 21-22 June (both clear, hot days) may have interfered with the male's ability to provide needed shade to these chicks. The lack of predation on chicks of this age class was surprising and may reflect insufficient sampling because it certainly must occur.

It is difficult to say how much the added stress of carrying radio transmitters contributed to mortality in 1979. We have nothing to compare the results of marginal viability with because no chicks were radioed in the nest cup during 1977 or 78. We suspect that if these six marginally viable hatchlings were going to survive without radios, they probably would have survived for more than a few hours with the radios.

Soon after learning to feed, curlew chicks began to gain weight and thermoregulatory capability. Once they reached this stage of development, their survival to fledging most likely depended on avoiding predation.

Predation pressures on radio-marked curlew chicks varied dramatically among years (Table II-13). In 1977 75% (9/12) of these chicks survived through fledging. One chick was predated by a long-tailed weasel, and fates of two others were unknown. In 1978 raptors were responsible for at least 62% (8/13) of all losses. No mortality was attributed to mammalian carnivores in 1978, but the fate of one radioed chick was unknown and it may have been predated by a mammal and carried underground. In 1979 predation was again light with just 4% (1/26) and 8% (2/26) of the samples being predated by raptors and mammals, respectively.

Abnormally heavy spring rainfall in 1978 resulted in unusually lush vegetative cover (vertical density and biomass). We suspect that this tall, thick vegetation on the BCPU reduced the vulnerability of small mammals to raptor predation. Curlew chicks, on the other hand, had difficulty moving about in this dense vegetation and favored more open areas where they were more vulnerable to visually hunting predators. We recorded no losses to raptors prior to 14 June, 1978, two days after most adult curlews departed. This emphasizes the importance of parental care for chick survival, and suggests to us that the abnormally early departure of attending adults facilitated a major shift in diet by the local raptors to include Long-billed Curlew chicks. The cause of this early departure by the adult curlews remains unclear to us, but we suspect that it was related to difficulties involved with foraging in the tall, dense vegetation with long bills.

The only other cause of mortality of radio-marked chicks was aspergillosis, a pulmonary mycotic infection from which 15% (2/13) perished in

Table II-12. Mortality of radio-marked Long-billed Curlew chicks aged 0-5 days

Year	Number Lost (%)	Mortality Attributed to: Marginal Viability[b]	Starvation	Predation	Thermal Stress	Unknown	N[c]
1977	0	-	-	-	-	-	3
1978	0	-	-	-	-	-	4
1979	12 (57)	6 (29)	2 (9.5)	0	2 (9.5)	2 (9.5)	21

[a] See Appendix Table II-3 for complete listing of individual radio-marked chicks and their fates.

[b] Chicks which died near their nests on day of hatching.

[c] Number of radio-marked chicks in sample, excluded are ones which shed radios and were subsequently lost.

Table II-13. Mortality of radio-marked Long-billed Curlew chicks regardless of age. [a]

Year	Number Radio-marked[b]	No. Surviving to Fledge (%)	No. Taken by Raptors	No. Taken by Mammals	Other Mortality Factors (%)	Fate Unknown[c]
1977	12	9 (75)	0	1 (8)	0	2 (17)
1978	13	2 (15)[d]	8 (62)	0	2 (15)[e]	1 (8)
1979	26	7 (27)	1 (4)	2 (8)	12 (46)[f]	4 (15)
Totals	51	18 (35)	9 (18)	3 (6)	14 (27)	7 (14)

[a] See Appendix Table II-3 for complete listing of individual radio-marked chicks.

[b] These figures do not include chicks which shed radios and were subsequently lost, unless 7 or more tracking days were accumulated; see Appendix Table

[c] These chicks probably died. The carcasses of one chick taken by a mammal and one taken by an owl were recovered from the openings of their burrows. We could not have detected the signals had the radios been deeper underground. If the radios failed on individuals in this column, the chicks would have died because we could not relocate them to loosen radio harnesses. This is not so for 3 chicks in this column from 1979 which shed their radios and were lost.

[d] Both these individuals were preyed upon post-fledgingly by raptors.

[e] Necropsies of both these individuals indicated probable cause of death to be a pulmonary mycotic infection (Aspergillus ssp.).

[f] See Table II-13 for fates of these 12 chicks aged 0-5 days.

1978. Aspergillosis has been reported from a wide range of free-living, avian species, particularly waterfowl and gamebirds (O'Meara and Witter 1971), but never from Long-billed Curlews.

Spores of Aspergillus species are widely distributed in nature and may be very common in and around moldy, organic environments (Gregory and Lacey 1963). In newly hatched, domestic birds, infection and rapid death can result from high exposure to Aspergillus spores (O'Meara and Chute 1959). But beyond this age, infection is thought to occur more often during periods of increased physiologic stress (O'Meara and Witter 1971).

Abnormal rainfall and increased vegetative biomass production on the BCPU in 1978 may have provided favorable conditions for Aspergillus fungus growth. Curlew chicks, inhabiting or passing through areas where this fungal growth was realized, undoubtedly were exposed to high levels of airborne spores. At the same time chick movements, and perhaps their feeding behavior as well, were impaired by the tall, dense vegetation. This in turn may have increased energetic demand and resulting nutritional stress on these chicks, thereby lowering their resistance to aspergillosis. Carrying a radio transmitter certainly did not benefit the chicks in 1978.

Juveniles

Only two radio-marked curlews were preyed upon post-fledging (Nos. 157 and 187). Both individuals were taken by raptors in 1978 and had only recently fledged. Again, we feel that it was the extraordinary conditions on the BCPU in 1978 that caused these losses. In 1977 and 79 we followed eight radio-marked chicks through fledging (No.s 48, 72, 80, 93, 243, 303, 306 and 307) and they all survived, presumably to depart from the BCPU.

We conclude that while post-fledging curlews are less vulnerable to predation, their chances of survival are greatly increased during fledging by the presence of attending adults, and later by gathering into large staging flocks.

Adults

We have no evidence of predation on adult curlews at any time on the BCPU. The fact that many clutches were lost to predators, often in twilight or complete darkness, suggests that adults incubating at this time can effectively detect and avoid mammalian carnivores. One instance of attempted raptor predation on an adult occurred in early April, 1979, when a Prairie Falcon (Falco mexicanus) flew from a perch on a nearby powerline pole and stooped on a female curlew that we had flushed from a nest. The adult curlew, alarmed by our presence, was performing a distraction display. Neither she nor the observers were aware of the falcon, approaching fast and low, until the last moment. The curlew jumped into the air and the falcon appeared to graze her as it passed. A moment later the falcon was gone from sight over a hill, and the female curlew remained overhead calling in alarm.

All adult mortality that we observed during this study was related to human disturbance activities on the BCPU. We found carcasses of nine adults along roads during May and June (8 in 1977, 1 in 1979). Three of these were shot with small caliber firearms, but the other six were too decomposed and

damaged to ascertain causes of death. However, we infer that these other six also had been shot because of their proximity to roads accessible to the public, and because it was the time of season when (1) many humans were using the BCPU for recreation, and (2) breeding adults were most vigorous in mobbing any intruder, human or otherwise.

In 1978 we found no shot birds, but we did encounter one adult female (No. 165) just north of Dewey Dump with a broken lower mandible. This female was unable to feed and had become to weak to fly. It is difficult to imagine how she might have incurred this damage, but she may have snagged it in some refuse littering the area, or she could have been shot. We also observed at least five different adults (3 in 1978, one each in 1977 and 1979) with damage to one leg or foot. Each would hop or hobble around on the ground with great difficulty and would usually fly with its damaged leg dangling down. We think it plausible that the abundance of broken glass and sharp metal edges (both resulting from shooting bottles and cans) as well as discarded wire and fencing in many areas of the BCPU might cause incidental harm to some adult curlews.

REPRODUCTIVE SUCCESS

Nests

Few of the 118 active Long-billed Curlew nests found during this study were monitored throughout egg-laying and incubation, and therefore, some nests must have been lost before we had a chance to find them. Nesting success and productivity rates which do not reflect these unknown losses are biased and underestimate actual clutch mortality (Mayfield 1961, 1975; Green 1977; and Miller and Johnson 1978 discuss this bias at length).

We used the Mayfield (1961, 1975) method for estimating annual rates of nest and egg destruction per day. Standard errors for these estimates were calculated after Johnson (1979). Multiplying a daily rate of nest success (1-rate of nest destruction) by itself 33 times provides an estimate of clutch survival for a 33 day nesting period (28 days for incubation and 5 days for egg laying). We calculated annual productivity ranges based on 95% confidence limits for both daily egg survival rates and mean number of eggs per nest (x eggs). The survival period was set at 33, 32, 30, and 28 days for each 1/4 of x eggs to account for egg survival throughout the egg laying period. Summing these four fractions gives an annual productivity value.

Clutch losses totaled 40% in both 1977 and 78 (12/30 and 16/40, respectively), but 46% (22/48) were lost in 1979 (Table II-14). As an indication of the extent of the bias in these figures, annual estimates of clutch mortality for a 33 day nesting period were about 50% greater than the observed values. The probability of clutch survival for 33 days was greatest in 1977 (40.4%), lowest in 1979 (34%), and intermediate in 1978 (37%). Approximate 95% confidence limits for estimates of daily survival rates suggest that differences among these estimates for the three years were not significant.

Single egg mortality rates per day were consistently greater than daily rates of clutch mortality. This difference was greatest in 1978 when 3.28% of the eggs versus 2.97% of the clutches were expected to perish each day (Table

Table II-14. Long-billed Curlew clutch survival.

Year	N[a]	Nests Lost	Nest-days[b]	Daily clutch rates (x 100)[c]		Rates for 33-day nesting period (x 100)	
				Mortality	Survival ± 2 SE	Mortality	Survival
1977	30	12	433	2.71	97.29 ± 1.54	59.6	40.4
1978	40	16	538	2.97	97.03 ± 1.46	63.0	37.0
1979	48	22	684	3.22	96.78 ± 1.35	66.0	34.0
Totals	118	50	1,665	3.00	97.00 ± 0.84	63.4	36.6

[a] Number of nests found during incubation

[b] Calculated as units of observed exposure (after Mayfield 1975); for example, one nest observed for a span of 10 days represents 10 nest-days.

[c] Daily mortality rates are calculated by dividing number of clutches destroyed by number of nest-days. Daily survival rate = 1-daily mortality rate. Multiplying these probabilities by themselves 33 times gives values for a 33-day nesting period.

II-14 and II-15). In any year this difference corresponds to losses of individual eggs from successfully hatching nests (see previous section on Mortality Factors).

Estimated chick production per nest was wide ranging for each year, reflecting the variability in both egg survival rates and mean numbers of eggs per nest. 1977 was clearly the more productive year with a mid-range estimate of 1.74 chicks produced (or eggs hatched) per nest (Table II-15). Hi-range estimates for 1978 and 1979 were comparable, whereas their lo-range estimates differed by about 20%. Chick production in 1978 probably exceeded chick production in 1979 by about 7%, while production in 1977 probably exceeded the 1978 rate by about 12%.

Because Long-billed Curlews are normally monogamous and lay just one clutch per season, the rate of chick production per breeding adult (h) is approximately 1/2 the rate of chick production per nest. This latter parameter, h, will be used for further discussions and calculations of annual reproductive success.

Chicks

Survival of curlew chicks from hatching through fledging (s_1) is difficult to measure because individuals cannot be monitored readily for the entire period of development. Fates of radio-marked chicks provided one indication of survival, but these data undoubtedly are biased for at least two reasons. First, because most chicks were monitored for less than the entire pre-fledging period we failed to record some mortality, and the observed survival rates through fledging represent overestimates of the actual survival. Second, carrying a radio transmitter and being disturbed regularly by investigators must increase mortality, not just in some direct way on very young chicks, but perhaps also indirectly on all age classes by increasing vulnerability to predation. These latter biases were not measurable, but to reduce the first bias we again used the Mayfield (1961) technique to calculate probabilities of survival for a 46 day pre-fledging period (Table II-16). These survival probabilities were remarkably different among years, and the extent of these differences still may reflect biases due to sampling methods and small sample sizes.

Differences among years can be understood best by breaking the 46 day pre-fledging period into three distinct chick age classes, and then comparing mortality within each age class among the three years (Table II-17). Age class I covers hatching through 5 days; during this critical period curlew chicks must learn to feed effectively. Age class II covers days 6-25 when relative chick growth rates are greatest, and when most chicks benefit from bi-parental care. Age class III (26-45 days) covers the reduction or cessation of parental care, family break-up, and fledging.

Survival probabilities of 100% for age class I in 1977 and 1978 were not reasonable and reflect insufficient sample sizes, particularly in 1978. Values between 65-85% chick survival to age 6 days are probably more accurate for these years, and we suspect that the average survival in 1978 decreased about 10% from 1977. The 40% survival figure for 1979 is likely to be an overestimate due to stress imposed on many newly hatched chicks by radio

Table II-15. Estimated Long-billed Curlew nest productivity

Year	Lost Eggs	Egg-Days	Daily Egg Rates (x 100)		Mean Eggs per Nest ± 2 SE	Range: Eggs Hatched/Nest		
			Mortality	Survival ± 2 SE		Hi	Mid	Lo
1977	49	1746	2.81	97.19 ± 0.79	3.96 ± 0.39	2.33	1.74	1.16
1978	70	2133	3.28	96.72 ± 0.77	4.00 ± 0.46	2.04	1.52	1.00
1979	83	2463	3.37	96.63 ± 0.73	3.73 ± 0.89	2.03	1.41	0.79
Totals	202	6324	3.19	96.81 ± 0.44	3.88 ± 0.70	1.95	1.48	1.02

Table II-16. Radio-marked Long-billed Curlew chick survival rates for pre-fledging period (0-45 days of age).

Year	N	% Lost	Chick-Days	Mortality/Day (x 100)	% Survival (s, x 100)
1977	12	25	303	1.0	63
1978	13	92	176	6.8	4.0
1979	26	62	365	4.4	13
Total	51	61	844	3.7	18

[a] 1 chick followed for 10 days represents 10 chick-days.

[b] Daily mortality rates calculated by dividing number of radioed chicks lost by number of chick-days. Multiplying each rate by itself 46 times gives an estimated mortality rate for the entire pre-fledging period.

Table II-17. Radio-marked Long-billed Curlew survival rates according to age class during pre-fledging period.

	I. Age 0-5 Days				II. Age 6-25 Days				III. Age 26-45 Days				
Year	n[a]	Chick-Days	m[b]	s[c]	n	Chick-Days	m	s	n	Chick-Days	m	s	N
1977	3	18	0	100	11	139	2.2	64	9	146	0	100	12
1978	4	4	0	100	11	101	7.9	19	5	71	5.6	32	13
1979	21	85	14	40	14	142	2.8	57	7	138	0	100	26
Total	28	107	11	50	36	382	3.9	45	21	355	1.1	80	51

[a] Number radioed chicks considered in each age class.

[b] Daily mortality rate (x 100).

[c] Survival rate for each age class (x 100).

transmitters. Average survival for this age class in 1979 may have been closer to 60%.

Sample sizes and sampling effort (given by number of radio-marked chicks followed in each age class, n, and number of chick-days in Table II-17) were adequate for age classes II and III in all three years. Assuming a minor increase in stress and vulnerability to predation for the radioed chicks, probabilities of survival for these age classes should underestimate slightly the actual survival rates.

Another index of chick survival can be based on resightings of color-marked juveniles which were originally banded as nestlings. But these figures also underestimate survival because of our inability to locate and resight all possible juveniles each year. During the 1977 post-fledging period we sighted 26% (15/57) of the chicks we had color-marked; in 1978 we saw 15% (8/55); but during the 1979 post-fledging period we saw none of the 38 color-marked chicks. Unfortunately, annual differences in post-fleging behavior patterns were so great that they masked any real differences in annual chick survival through fledging. In 1977 we observed flocking juveniles from July 16 - August 13 (x = 75 birds/day for 28 days); in 1978 we saw more birds in an equal time span from 11 July - 9 August (x = 124 birds/day for 28 days). However, in 1979, juveniles did not flock regularly, and in spite of having four observers in the field compared to two in each of the previous summers, we saw flocks only betwee 28 July and 6 August (x = 71 birds/day for 10 days). In the summer of 1979, single juveniles and small groups of 5-10 were seen regularly.

As might be expected, chick survival rates based on resightings of color-marked juveniles differ remarkably from calculated probabilities based on radio-marked chicks. In both 1977 and 1979 these observed survival rates of marked birds (26% and 0%) were considerably less than calculated rates (63% and 13%). But in 1978 observed survival exceeded the calculated survival rate (15% vs. 4%). We suspect that radio-marking chicks in 1978 (when parents abandoned chicks at earlier ages than in 1977 and 1979) may have increased their vulnerability to raptor predation, and hence may have caused greater mortality within our sample than among non-radioed individuals.

Population

Mortality rates on different curlew age classes varied from year to year, depending on predation measures, intensity and duration of parental care, climatic factors, food availability, human disturbance, etc. (see previous section on Mortality Factors). The question remains: are the reproductive rates described above sufficient to maintain the curlew population on the BCPU? Unfortunately it was not possible to provide a precise answer with only three years of data.

For this curlew population to be stable or to increase in numbers, the annual recruitment rate of new breeders into the population must be equal to or greater than the annual adult mortality rate. If we make the assumption that emigration equals immigration for this population, then the annual rate at which adult curlews produce offspring that survive to breed at least once

(l_b) is an indirect measure of annual recruitment, and can be calculated (Soikkeli 1970) by the equation:

$l_b = h \times s_1 \times s_2 \times s_3 (a + bS)$, where
l_b = proportion of an adult's annual offspring surviving to breed,
h = average number of chicks hatched/breeding adult/year,
s_1 = proportion of chicks (h) surviving to fledge,
s_2 = proportion of juveniles (s_1) surviving to age 2 years,
s_3 = proportion of sub-adults (s_2) surviving to age 3 years,
a = proportion of s_3 breeding first at age 3 years,
b = proportion of s_3 breeding fist at age 4 years, and
S = annual survival rate of 3 year olds and adults.

We have already discussed the biases, results, and annual variability of the h and s_1 parameters in preceeding paragraphs (see Tables II-15, 16, and 17). Several of the other demographic parameters are unknown for Long-billed Curlews and must be estimated. We consider values for $s_2 = 0.55$ and $s_3 = 0.75$ to be reasonable based on figures for European Curlews (Boyd 1962). Age at first breeding, parameters a and b, have not been determined; however, it is likely that some females returning as 3 year-olds probably breed ($a = 0.2$, both sexes included) and that the remaining birds probably breed for the first time at age 4 years ($b = 0.8$). In 1978, the minimum annual adult survival rate was $S = 0.89$, based on the return of 8/9 color-marked adults. This figure was substantially lower in 1979 ($S = 0.63$); but again, vegetative conditions on the BCPU early that spring may have discouraged many returning adults from remaining to breed. Annual adult survival (S) probably varies between 0.75 and 0.90 with 0.85 being a reasonable average estimate.

Calculations of l_b based on high, medium, and low levels of estimation of demographic parameters for each year are more variable within than between years (Table II-18). Reproductive rates in 1977 ($5.94\% \leq l_b \leq 22.8\%$) were considerably better than in 1978 or 79 ($1.82\% \leq l_b \leq 17.9\%$) (Table II-18). With adult survival averaging 85% per year, 15% of the breeding adults must be replaced annually to maintain long term population stability. This in turn would require $l_b \geq 15\%$, a figure which is exceeded by our high levels of estimation for all three years.

Looking at population dynamics from a different perspective, we would expect that on the average an individual curlew during its lifetime should produce a total $\Sigma\, l_b \geq 1.0$ offspring which survive to breed, if the population is not declining. Therefore, it would take $1/l_b$ breeding seasons for an individual to reproduce itself in the breeding population of the BCPU, assuming a constant annual rate, l_b. While for most years this is probably an unrealistic assumption, such an approach allows one to more easily interpret the range and biological significance of the estimates. By assuming age at first breeding to average 3.8 years, and adding this figure to the required number of breeding seasons for self-reproduction, we can estimate the total number of years, on the average, an individual curlew must survive (L_e). These figures vary between 8 and 59 years depending on year and estimate (Table II-18).

Long-billed Curlews are of similar body size to European Curlews, and therefore may have a similar potential longevity (Bourliere 1946). Survival of an individual European Curlew has exceeded 32 years in the wild (Boyd

Table II-18. Estimations of Long-billed Curlew reproductive parameters on the BCPU.

Year	Level of Estimation*	Reproductive Rate Parameters								Longevity (Le)
		h*	s_1*	s_2	s_3	a	b	S*	l (x 100)	
1977	Hi	1.20	0.60	0.55	0.75	0.2	0.8	0.90	27.3	7.46
	Mid	0.90	0.45					0.85	14.7	10.6
	Lo	0.65	0.30					0.75	6.44	19.3
1978	Hi	1.05	0.40	0.55	0.75	0.2	0.8	0.90	15.9	10.1
	Mid	0.85	0.25					0.85	7.71	16.8
	Lo	0.55	0.10					0.75	1.82	58.9
1979	Hi	1.05	0.45	0.55	0.75	0.2	0.8	0.90	17.9	9.39
	Mid	0.75	0.30					0.85	8.17	16.0
	Lo	0.45	0.15					0.75	2.23	48.7

* Values for h, s_1, and S are all rounded up to the next 0.05 level to compensate investigator induced mortality. Thed mid values are based on average measurements while the hi and lo values bracket extreme measurements.

1962), suggesting that curlews are potentially long-lived birds. The average life expectancy of an adult starting to breed (L_B) can be estimated by the equation:

$$L_b = 1.0/M - 0.5 ,$$

where M = 1 - S or the periodic adult mortality rate, which is assumed to be constant (Farner 1949). For adult curlews, entering the breeding population on the BCPU, the average future life expectancy = 1.0/0.15 - 0.5 = 6.2 years. Thus their average total life expectancy is 6.2 + 3.8 or about 10 years.

Clearly, there are too many unknowns for us to draw precise conclusions about the demography of Long-billed Curlews on the BCPU. However, all of the evidence suggests that these birds are long-lived and pursue a very conservative breeding strategy in order to optimize future breeding opportunities. The population probably can tolerate the low annual recruitment rates implied by these data (particularly from 1978 and 79) as long as adult mortality remains low, and enough individuals are able to take advantage of highly productive seasons whenever they occur. In such a population adult individuals and their future breeding potential are extremely important, especially as compared to an individual egg or clutch. In order to insure the stability of this population, adult curlews must be protected.

FOOD HABITS AND FEEDING BEHAVIOR

Methods

Evaluation of the Long-billed Curlew diet on the BCPU is based on field observations from three complete breeding seasons and the examination of nine stomach contents collected during June-July, 1977 and 1978. Fresh stomachs were stored frozen until their contents could be removed in the lab and placed in 70% ETOH. Sorting and analysis of these stomach contents samples were performed by George B. Kirsch at the University of Montana, Department of Zoology. Classification and terminology for insects and spiders follows Borror and DeLong (1971).

Nine curlew stomachs were collected from recently predated birds during June-July, 1978, but only six of these contained identifiable material. All six were from chicks aged 14-46 days. In addition, three curlew chicks (aged 34-44 days) provided regurgitated stomach contents samples (one each) during July, 1977, and 1978. As an emetic, we introduced a 1% solution of antimony potassium tartarate directly into the proventriculus at a dosage of 0.4 cc/100 body weight (modified after Prys-Jones et al. 1974). These chicks all weighed at least 300 g when treated. They were also radio-marked at this time and their subsequent growth and development monitored for a minimum of 4 days post-treatment. All three chicks survived this period with no visible ill effects from the emetic.

Not only is our food habits study biased by the small sample of curlew stomachs collected during a limited time period, but this bias is compounded by problems inherent to stomach contents analyses (Hartley 1948, Koersfeld 1951). Because various prey items are digested at different rates, and because the effects of gastric juices do not terminate at death, our ability

to identify all material from these stomachs was limited. For example, identifiable remains of soft-bodied insect larvae or spiders might not be detectable in a freshly collected stomach twenty minutes after ingestion, whereas the chitinous parts of an adult carabid beetle or grasshopper might persist in such a stomach for several hours (Custer and Pitelka 1975). Our data probably underestimates the diversity of prey types taken by the Long-billed Curlews.

Results and Discussion

On the BCPU, curlews fed by picking and gleaning prey from the ground and vegetation. They were capable of probing with their long bills wherever the substrate permitted; and we observed adults probing into spider burrows as well as moist or loose soils on surrounding agricultural lands. Although curlews used their long bills infrequently for probing on upland breeding grounds, they allowed the curlews to maintain a visual plane above the vegetative cover while feeding. From this perspective their eyes were safer from accidental damage and this vantage allowed for better detection of predators. The vast majority of curlew feeding on the BCPU from March-July is from the ground surface (Fig. II-7).

The incidence of probing by foraging adults was greatest in March and early April. We suspect that spiders were an important component of the curlew diet during the pre-laying period in 1977 and 1978. The reduced vegetative cover on the BCPU these years rendered spider burrows very conspicuous. Careful retracing of routes taken by foraging curlews at these times revealed many spider burrows and occasional carabid beetles. Curlews feed on trapdoor spiders (family Ctenizidae) during early April on grassy uplands in southern California (Abbot 1944).

The massive quantity of residual, standing dead vegetation covering much of the BCPU in the spring of 1979 appeared to cause a dramatic shift in the curlews' selection of feeding sites, and hence probably in their food habits during March and April. Flocks of up to eighty adults were seen feeding daily on large earthworms and other invertebrates in agricultural fields south of the BCPU. These flocks preferred freshly plowed fields and wet pastures. By contrast, in March and April of 1977 and 1978 we saw curlews in surrounding agricultural lands only irregularly. In these years most curlews fed primarily on or near their upland territories and active defense of these areas was the general rule.

As ambient temperatures increased in April and May, curlews relied more on prey moving on the ground surface. Carabid beetles were quite conspicuous and commonly encountered over the BCPU in all three years at this time. We suspect that they were an important food resource to curlews prior to the annual eruption of grasshopper species. Barrs (1979) presents data on movement patterns of carabid beetles that appear relevant to their vulnerability to Long-billed Curlew predation.

In both 1977 and 1979 grasshoppers became available to curlews on the BCPU in mid-May. In 1978, however, we did not encounter sizeable numbers of grasshoppers until three or four weeks later. This situation may have placed some stress, especially on curlew chicks during late May and early June, 1978.

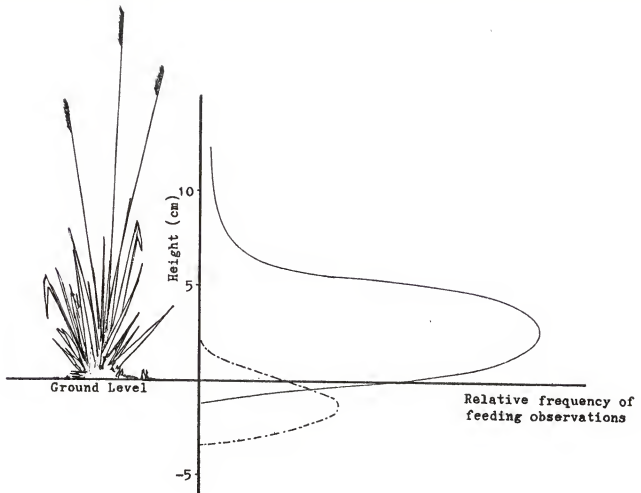


Fig. II-7: A qualitative interpretation of Long-billed Curlew feeding strategies on the B.C.P.U.
Legend: ·-·-·-·-·- March-April
_____ April-July

The results of the nine stomach contents analyses were surprising (Table II-19). All were collected in June and July after grasshoppers had become readily available, but coleopteran body parts (carabid beetles in particular) were still well represented. We infer that while grasshoppers might have been more numerous, their mobility reduced their overall vulnerability to young curlews. Conversely, a slow-moving, black beetle, once encountered was easy prey. The similarity in diet between curlew chicks from the BCPU and two adult birds collected from the Cottonwood site of the IBP Grassland Biome in northeastern Colorado (Wiens et al. 1970) is also striking (Table II-19).

By early July most chicks had fledged and ambient temperatures often exceeded 35°C. The juvenile curlews began to form flocks and to feed in early mornings and evenings in regions of high grasshopper density on the BCPU. Unfledged curlews spent the warmest daytime hours in shade. Fledged young flew to irrigated agricultural lands surrounding the BCPU. Only rarely did we witness bouts of feeding behavior by these flocking juveniles at irrigated agricultural sites, and we assume that this mid-day behavior pattern served as a thermoregulatory rather than a feeding function.

We consistently observed flocking juveniles exploiting grasshopper populations during July. This was most apparent in late July of 1977 and 1979 when grasshopper numbers were greatest. At these times, the flocking curlews moved in broad phalanxes across ridges harvesting grasshoppers as they walked. Black-billed Magpies, Western Meadowlarks, and American Kestrels occasionally joined the curlews to form temporary, mixed-species feeding guilds, all exploiting this abundant food source.

We conclude that Long-billed Curlews are very opportunistic feeders, capable of utilizing a wide variety of prey types according to what is most available and vulnerable. Data in Table II-19 support this contention, especially when the biases associated with these data are considered. Furthermore, we observed curlews eating maggots from different animal carcasses on several occasions, and Sadler and Maher (1976) report two observations of adult curlews consuming Horned Lark nestlings in Saskatchewan. Upland feeding on berries is casually referred to by Wickersham (1902); while two stomachs from the BCPU contained plant material, we assume this was ingested accidentally.

Curlews selected wide open habitats in which to feed and appeared to catch whatever was available in those habitats. The selection was not on the level of specific food items but at the level of the place in which they can feed. Curlews fed in those habitats which provided them with the best visibility and allowed them to detect potential predators at a maximum distance. It is also possible that curlews cannot feed effectively in dense tall vegetation because of their long bills, and that they can feed effectively only in open areas.

Table II-19. Stomach contents of nine Long-billed Curlew chicks from the BCPU and two adults from northeast Colorado.

	BCPU		NE Colorado[1]	
	N	% Freq. Occ.	% Freq. Occ.	% dry wt.
Insecta				
Orthoptera	9	100	100	76.4
Coleoptera	8	89	100	22.7
Hemiptera	1	11	50	tr.
Lepidoptera (larvae)	1	11	100	0.8
Hymenoptera	1	11	50	tr.
Aracnida				
Araneida	1	11	50	0.1

[1] Wiens et al. 1970.

CHAPTER III

THE BLACK CANYON PLANNING UNIT (BCPU)

VEGETATION

The study area portion of the Black Canyon Planning Unit (BCPU) contained about 67,000 acres (27,000+ ha) of rangeland. The area is characterized by choppy to rolling topography which supports a semi-desert type vegetation. Pre-settlement dominant plants were sagebrush (Artemisia tridentata) and perennial herbs included tall grasses and forbs (Davis 1952). The once widespread sagebrush was nearly eliminated by fire. Only relict colonies of sagebrush remain among the short and tall grasses that presently dominate the area.

Methods

We sampled vegetative structure in all available habitat on the BCPU study area. The samples included vegetative strata used by curlews (use-areas) as well as strata the curlews did not use (non-use areas). Sampling was conducted in June 1977 and between 1 April and 15 July in 1978 and 1979. Numerous vegetation areas can be distinguished on aerial photographs of the BCPU. Contrasts in tone of the photographs created a pattern of 28 course divisions when traced on a map of the BCPU. The lines dividing the 28 areas correspond to fence lines, boundaries created by crested wheatgrass plantings, or different management regimes. Vegetation on the two largest areas varied continuously. We divided each of them into 2 smaller areas. Hence we defined a total of 30 vegetation "types" on the BCPU study area and vegetation sampling and analysis is based on these 30 divisions (Figure III-1).

We sampled vegetation structure in June 1977 by systematically establishing 100, one-kilometer transects along previously established curlew census routes so that all vegetation types were sampled. One hundred 0.10 square meter (m^2) frames were located in a stratified random fashion, along each one-kilometer transect so that each aspect, hilltop, and depression was represented in the sample.

In 1978 and 1979 we sampled vegetation structure for the periods 1 April to 15 July by randomly placing 480 frames of 0.10 m^2 on each of the 30 vegetation types identified during the 1977 season. We located eight 0.5 kilometer transects corresponding to the eight cardinal compass points at twelve randomly determined points in each of the 30 vegetation types. Five randomly placed frames were then located on each of the eight transects. We repeated this procedure at two-week intervals both years.

We recorded: species composition, percent coverage, and density of each plant species; percent coverage of bare ground, and total canopy coverage in each of these 0.10 m^2 frames using procedures described by Daubenmire (1959). Height of the vegetation in each frame was determined by placing a meter stick vertically in the center of the frame and recording the highest point at which plants touched the stick. We also recorded for each frame; disturbance or management regime, date of disturbance, aspect, slope, and degree of soil rockiness.

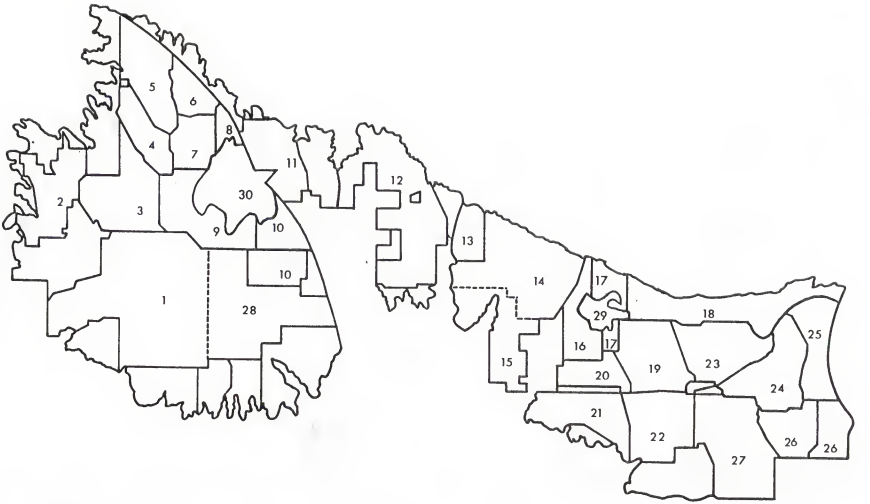


Fig. III-1: Location of 30 vegetation types on the BCPU.

We sampled vertical coverage of vegetation at one randomly chosen point per forty 0.10 m^2 frame placements. We viewed a 1.5 m x 0.25 m vision board, placed horizontally at the random point, from five distances (5, 10, 15, 20, 25 m) along a transect at right angles to the face of the board. The board was viewed from 3 dm above the ground in an attempt to imitate the height of the curlew eye (Figs. III-2, -3). We recorded six coverage values for each of the five viewings using a Braun-Blanquet (1932) coverage scale (1 $\leq$ 10% coverage, 2 = 11-25%, 4 = 51-75%, 5 = 76-95%, 6 $\geq$ 96%). We systematically established ten 0.5-kilometer transects through each of five important sagebrush stands on the BCPU. Twenty random points along each transect served as the centers for the evaluation. In each of the four quarters we measured the distance to the nearest woody plant from the center, its diameter, height and species.

To determine above ground vegetative productivity we hand harvested all plant material within one 0.10 m^2 frame per twenty sampled during June and July 1978 and 1979. We oven dried each sample for 24 hours at 55°C and weighed it to the nearest 0.1 gram. Vegetative structure data were recorded directly onto FORTRAN coding sheets to facilitate analysis.

General Results

Analysis and description of the vegetation structure on the BCPU was very difficult and complex. The vegetation on each of the thirty vegetation types was affected by a unique set of disturbances which vary within and between seasons as well as spatially. The vegetation reacts to these disturbances with a similar pattern of variation, however, many effects of disturbance are long lasting. An alteration in vegetation structure may be occurring at the same time vegetation is recovering from a previous disturbance. It is most likely that at any time during the curlew breeding season, the vegetation on any vegetation type is recovering from several disturbances. The seasonal succession of the vegetative strata in each type is, therefore, unique and extremely dynamic. In general, there are four kinds of vegetation on the BCPU, short grass range, sagebrush stands, crested wheatgrass plantations and areas converted to agriculture (Fig. III-4).

The description of the vegetation is organized to describe its state on each of the 30 areas during the spring and summer seasons when it is important to curlew biology. We divided 1978 and 1979 into four time periods each: pre-laying (23 March - 8 April 1978 and 25 March - 18 April 1979), laying (9-15 April 1978 and 19-21 April 2979), incubation (16 April - 13 May 1978 and 26 April - 23 May 1979), and brood rearing (14 May - 15 July 1978 and 24 May - 1 July 1979). Curlew requirements potentially differ during these different phases of their reproductive cycle.

BCPU Plant Species Composition

We identified 48 plant species on the BCPU rangeland during this study (Table III-1). Only 20 species of plants were identified on the BCPU during the severe drought conditions of 1977. Twelve species, five grasses and seven forbs are of Old World origin and are frequent invaders of dry disturbed areas (Davis 1952, Gleason and Cronquist 1963). The vegetation of the BCPU was characterized by eight most important plant species in 1977 and by 16 most important plant species in 1978 and 1979 (Table III-2). Importance of a plant

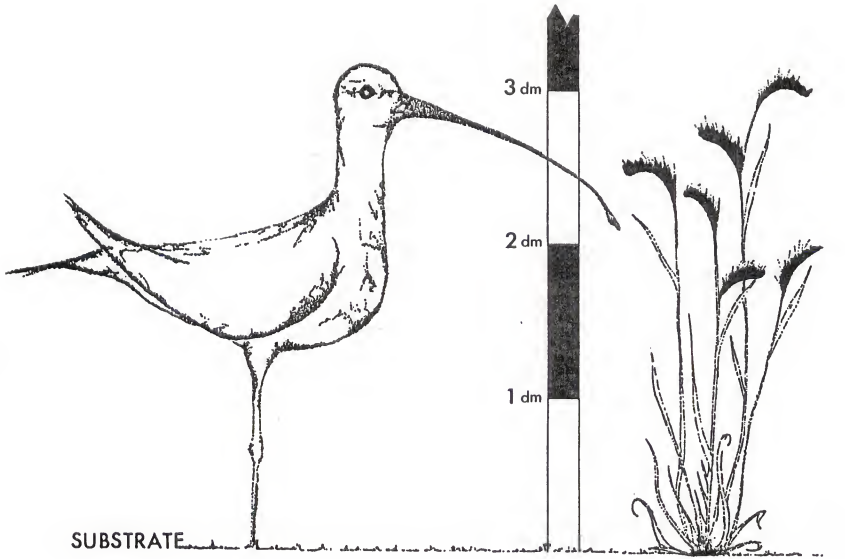


Fig. III-2: Vertical coverage is evaluated from 3 dm above the ground in attempt to imitate the height of the curlew eye.

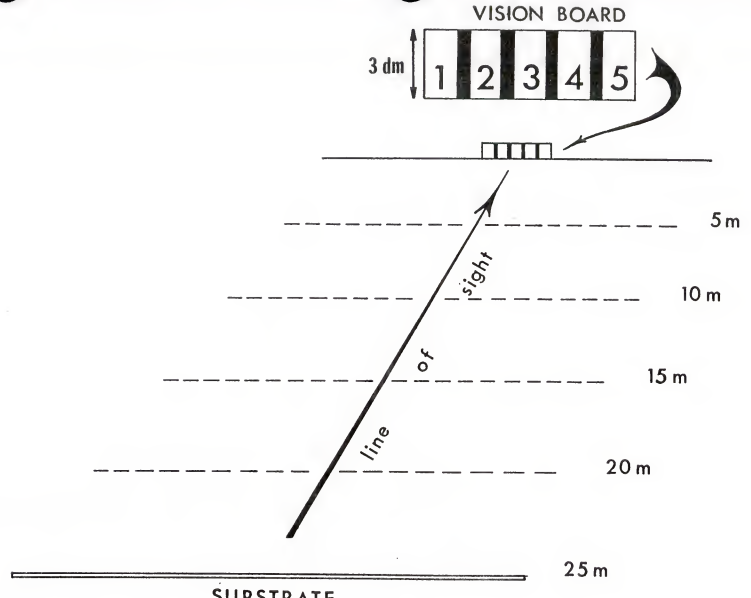


Fig. III-3: Percent vertical coverage of vegetation measurements were taken from five distances from the vision board. Measurements were taken 3 dm from ground level to imitate the height of the curlew eye.

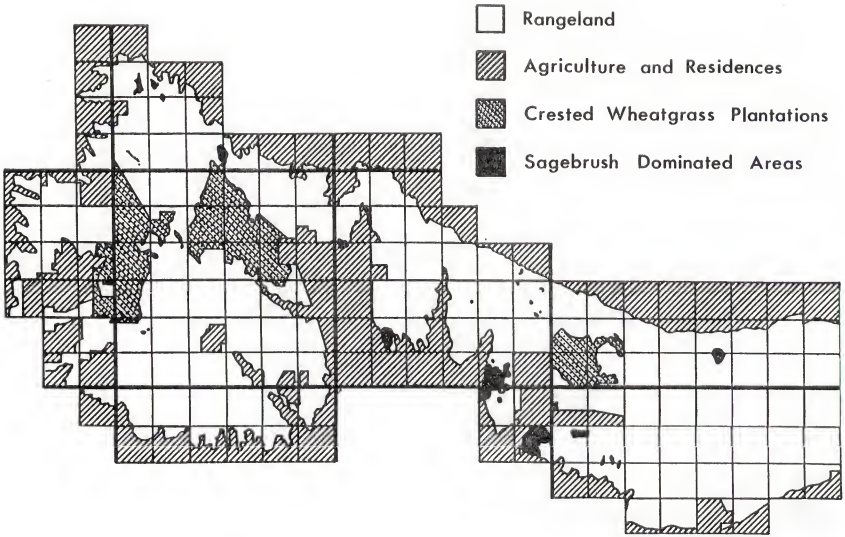


Fig. III-4: Location and extent of four kinds of vegetation on the BCPU.

Table III-1. Plant species occurring on the Black Canyon planning unit: 1977-1979.

	Scientific Name	Common Name	Abbreviation
	GRASSES		
1	Agropyron cristatum	Crested wheatgrass	AGCR
2	Agropyron spicatum	Bluebunch wheatgrass	AGSP
3	Alopecurus spp.	Foxtail	ALOPE
4	Aristida longiseta	Red Threeawn	ARLO
5	Bromus tectorum	Cheatgrass brome	BRTE
6	Elymus cinereus	Giant wildrye	ELCI
7	Festuca bromides	Six weeks fescue	FEBR
8	Hordeum jubatum	Foxtail barley	HOJU
9	Koeleria cristata	Prairie junegrass	KOCR
10	Poa bulbosa	Bulbous bluegrass	POBU
11	Poa pratensis	Kentucky bluegrass	POPR
12	Poa sandbergii	Sandberg bluegrass	POSA
13	Sitanion hystrix	Bottlebrush squirreltail	SIHY
14	Stipa thurbiana	Thurber neddlegrass	STTH
15	Stipa comata	Needle-and-thread	STCO
16	Taeniatherum asperum	Medusahead wildrye	TAAS
	FORBS		
17	Ambrosia artemisifolia	Common ragweed	AMAR
18	Amsinckia tessellata	Tessellate fiddleneck	AMTE
19	Astragalus purshii	Pursh locoweed	ASPU
20	Cryptantha circumscissa	Matted cryptantha	CRCI
21	Delphinium spp.	Larkspur	DELPH
22	Draba verna	Spring draba	DRVE
23	Epilobium paniculatum	Autumn willoweed	EPPA
24	Erodium cicutarium	Storksbill	ERCI
25	Eriastrum sparsiflorum	Eriastrum	ERSP
26	Gilia spp.	Gilia	GILIA
27	Helianthella spp.	Helienthilla	HELIA
28	Holosteum umbellatum	Jagged chickweed	HOUM
29	Lactuca serriola	Prickly lettuce	LASE
30	Lepidium perfoliatum	Clasping pepperweed	LEPE
31	Machaeranthera canescens	Hoary aster	MACA
32	Microsteria gracilis	Pink microsteris	MIGRA
33	Mimulus nanus	Dwarf monkeyflower	MINA
34	Oenothera contorta	Plains evening primrose	OECO
35	Oenothera pallida	Pale evening primrose	OEPA

Table III-1. Plant species occurring on the Black Canyon planning unit: 1977-1979 (continued).

	Scientific Name	Common Name	Abbreviation
FORBS			
36	Opuntia fragilis	Brittle prickly pear	OPFR
37	Opuntia polycantha	Plains prickly pear	OPPO
38	Penstemon spp.	Beard tongue	PENST
39	Phacelia linearis	Threadleaf phacelia	PHLI
40	Phlox aculeata	Idaho phlox	PHAC
41	Salsola kali tenuifolia	Russian thistle	SAKAT
42	Sisymbrium altissimum	Tumblemustard	SIAL
43	Sphaeralcea spp.	Globemallow	SPHAE
44	Tragopogon dubious	Yellow salsify	TRDU
45	Zigadenus spp.	Deathcamas	ZIGA
SHRUBS			
46	Artemisia arbuscula	Low sagebrush	ARAR
47	Artemisia tridentata	Big sagebrush	ARTR
48	Purshia tridentata	Antelope bitterbrush	PUTR

Table III-2. Alphabetic list of abbreviations used in the Tables and Figures for scientific names of plants. These are the 16 most important species on the BCPU.

Abbreviation	Scientific Name
AGCR	Agropyron cristatum
AMAR	Ambrosia artemissifolia
AMTE	Amsinkia tesselata
ARLO	Aristida longiseta
BRTE	Bromus tectorum
LEPE	Lepidium perfoliatium
ELCI	Elymus cinereas
ERCI	Erodium cicutarium
FEBR	Festuca bromoides
MACA	Macaeranthera canescens
PHAC	Phlox aculeata
POBU	Poa bulbosa
POSA	Poa sandbergii
SIAL	Sisymbrium altissimum
TAAS	Taeniatherum asperum
TRDU	Tragopogon dubius

species is measured as an Importance Value (IMPV), which is the sum of: relative frequency, relative coverage, and relative density for each species. We calculated importance values for June 1977, and for each part of the curlew breeding cycle during 1978 and 1979. The top five ranking plant species (according to importance values) in each of the 30 vegetation types in 1977, 1978 and 1979 are presented in Tables III-3, III-4 and III-5 respectively.

Cheatgrass brome was the dominant species on the BCPU. From 1977 to 1979 cheatgrass brome dominated 37 to 63% of the 30 BCPU vegetation types. It ranked either one or two in importance in 28 of the 30 vegetation types during the 1977 brood-rearing period (Table III-3). Cheatgrass brome varied in importance within a single year depending on time of year; it dominated 14 to 19 vegetation types in 1978 breeding season and 15 to 19 vegetation types in 1979 (Table III-4,5). Cheatgrass brome maintained its importance for the different portions of the breeding season in different ways. In April its high density values gave it a high importance value. As the season progressed, its increasing horizontal coverage values maintained its score as the top dominant through July, when it attained its maximum coverage, density, and frequency. Although this annual was not a living component of the vegetative community in July, it was the most important physical vegetative structure in the area.

Other cool season grasses occasionally dominated some vegetation types. Medusahead wildrye (Taeniatherum asperum) dominated 10 of the 30 vegetation types during the brood-rearing period in 1977 and 78 and 9 types in 1979. This cool season annual increased in importance through the breeding season and hence dominated more vegetation types in the latter periods than in the early periods of the breeding season because of an increase in coverage as the plants mature.

In addition to dominating a substantial proportion of the BCPU, medusahead wildrye was also an important component of types dominated by cheatgrass brome. It was the second most important plant species on 9 vegetation types in 1977, 7 to 11 in 1978 and 7 to 15 in 1979. Medusahead wildrye ranked within the 5 most important species in 27 of the 30 vegetation types in June 1977, in 23 (pre-laying) to 27 (laying) types in 1978 and 25 (pre-laying) to 28 (brood-rearing) types in 1979.

Other cool season plant species which dominated vegetation types at some time were Sandberg bluegrass (Poa sandbergii), bulbous bluegrass (Poa bulbosa) six weeks fescue (Festuca bromoides) and storksbill (Erodium cicutarium).

Sandberg bluegrass dominated vegetation type 10 in 1977 and vegetation type 3 during pre-laying and laying periods in 1978. This perennial bunchgrass varied moderately in importance from year to year, however, its importance varied mostly due to changes in the abundance of other species and their varying response to differences in annual rainfall and not because its abundance changed drastically.

Bulbous bluegrass dominated vegetation types 1, 2, 9, and 10 during the pre-laying and laying periods and type 10 during the incubation period of the breeding season 1978. It's importance in 1978 may be partially attributed to the usually wet growing season of the year. The importance values of this

Table III-3. The top five ranking plant species (according to importance values) in each of the 30 vegetative types in June, 1977. Abbreviation of plant species are arranged alphabetically in Table III-2.

Type	BRTE	TAAS	POSA	ELCI	AMAR	TRDU	PHAC	AGCR
1	1	3	2	5	5		4	
2	2	1	3	4	5			
3	1	4	2	5		5	3	
4	1		2	3			4	5
5	1	4	2	5			3	
6	1	4	2	3			5	
7	1		2	3		5	4	
8	1	2	3	4			5	
9	1	5	2				3	4
10	2		1	5			4	3
11	2	1	3	4		5		
12	2	1	3	5	4	4		
13	1	2	3	4			5	
14	2	1	4	3			5	
15	2	1	3	4			5	
16	2	1	3	5			4	
17	1	2	3	5			4	
18	1	2	3				5	4
19	2	1	3	5				4
20	2	1	3	4		5		
21	1	2	3	4		5		
22	1	2	3	4	5	4	4	
23	1	2	3	5			4	
24	1	2	3	4		5		
25	1	2	3	4		5		
26	2	1	3	4			5	
27	2	1	3	4			5	
28	1	4	2		5	5	3	
29	5	5	2	5	5	3	4	1
30	3	5	2				4	1

Table III-4. The top five ranking plant species (according to importance value) in each of the 30 vegetative types in each period of the curlew breeding season 1978. Abbreviations are found in Table III-2.

Prelaying, 23 March - 8 April 1978

Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	2	1	4					3					5			
2	2	1	4	3				5								
3	2	3	4		1			5								
4	1	2	5		3		4									
5	1	4	2		3		5									
6	1	3	2		4			5								
7	1	2	4		5			3								
8	1	4	5	2				3								
9	2	1	5	3				4								
10	3	1	2	4				5								
11	1		5	3	2			4								
12	2		4	5	3			1								
13	5	4	3	1				2								
14	1	5		2	4			3								
15	1	2		3	5			4								
16	1	5	4	2				3								
17	1	3		2	4			5								
18	2		1	4	5			3								
19	2			4	3		5	1								
20	2	5	3	1				4								
21	1	3	5	4				2								
22	2	3		1	5			4								
23	1	5	3	2				4								
24	1	5	4	2				3								
25	3	5	2	1				4								
26	2	5	3	1				4								
27	2	5	4	1				3								
28	1	5	2	4				3								
29	2	4			3			5								1
30	3	5	4	2												1

Table III-4. Continued.

	Laying, 9-15 April, 1978															
Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	2	1	3	5				4								
2	2	1	4	3	5											
3	2	3	4	5	1											
4	1	2			3	5	4									
5	1	4	3	2		5										
6	1	2	3		4	5										
7	1	2		5	4			3								
8	1	3	5	2				4								
9	3	1	4	2				5								
10	3	1	2	4				5								
11	1		4	2	3		5									
12	1		5	4	2			3								
13	3	5	4	1				2								
14	1	5		2	3			4								
15	1	3		2		5		4								
16	1	5	3	2				4								
17	1	3		2	4			5								
18	2		3	1	4			5								
19	1			5	4		3	2								
20	1		3	1				5			4					
21	1	3	4	2				5								
22	1	3		2	5			4								
23	2	3	4	1				5								
24	1	5	3	2				4								
25	2	4	3	1				5								
26	2	5	3	1				4								
27	2	5	3	1				4								
28	1	5	2	3				4								
29	2	4			3					5						1
30	1	3	2	4					5							1

Table III-4. Continued.

Incubation, 16 April - 13 May 1978																
Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2	4	3				5								
2	2	3	5	1		4										
3	1	3		4	2							5				
4	1	2			5	3	4									
5	1	4	3		5	2										
6	1	2		4	3	5										
7	1	3	5		4	2										
8	1	3		2		4				5						
9	3	2	4	1					5							
10	2	1	3	4			5									
11	1			2	3	5	4									
12	1	5		2	3	4										
13	2		4	1		5		3								
14	1	4		2	3		5									
15	1	3		2		4		5								
16	1		3	2				5			4					
17	1	4		2	3								5			
18	2		3	1	4			5								
19	1						3	4	5	2						
20	2		3	1			5					4				
21	1	3	5	2										4		
22	2	3		1	4								5			
23	1	3	4	2												
24	1	4	3	2					5							
25	2	5	3	1				4		5						
26	2		3	1	4	5										
27	1		3	2	5	4										
28	1		2	3	4						5					1
29	2	3			5						4					1
30	2	4	3	5												

Table III-4. Continued.

Brood-rearing, 14 May - 15 July 1978																
Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2	4	3				5								
2	2	3		1		4			5							
3	1	3	5	4	2											
4	1	2			5	3	4									
5	1	4		2	3	5										
6	1	3		2	4	5										
7	1	3			4	2				5						
8	1	3		2		5			4							
9	2	3	4	1		5										
10	2	3	4	1			5									
11	1			2	3	5	4									
12	1			2	4	3					5					
13	2	3	5	1				4								
14	2			1	3					5		4				
15	1	4		2		3			5							
16	1		3	2						4					5	
17	1	3		2	4				5							
18	2			1	3			4	5							
19	1				5		3		4	2						
20	2		3	2			5					4				
21	1	3	4	2											5	
22	2	3		1	4				5							
23	1	3	4	2					5							
24	1		4	2						3		5				
25	3	5	2	1						4						
26	2		3	1		5						4				
27	1		2	3		4			5							
28	1		2	3		5			4							
29	2	4			3						5					1
30	2	5	3	4												1

Table III-5. The top five ranking plant species (based on importance value) in each of the 30 vegetative types in each period of the curlew breeding season 1979. Abbreviations are found in Table III-2.

Prelaying, 25 March - 18 April 1979

Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2	4					3					5			
2	1	2	3	4				5								
3	1	3	4	2	5											
4	1	2	5	3				4								
5	1	4	2	5				3								
6	1	2	3			5		4								
7	1	3		4	5			2								
8	1	5	4	2				3								
9	2	1		3	5			4								
10	3	2		4				5								
11	1		3	4	2	5										
12	3	4	5		2			1								
13	3	4		1	5			2								
14	2		5	1	4			3								
15	3	2		1	5			4								
16	1	5	4	2				3								
17	1		4	2	3			5								
18	4		2	1		5		3								
19	1			4	3		5	2								
20	2	5	3	1				4								
21	1	3	5	4				2								
22	1	2		4	5			3								
23	1	5	3	2				4								
24	1	3	5	2				4								
25	2	5	3	1				4								
26	2	5	4	1				3								
27	1	5	4	2				3								
28	1	4	2		5			3								
29	2	4			3			5								1
30	2	4	3	5												1

Table III-5. Continued.

	Laying, 19-25 April, 1979															
Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2		4				3			5					
2	2	4	3	1				5								
3	1	3	5	2				4								
4	1															
5	1		4	3	5	2										
6	1	4	2		3	5										
7	1	2	5	3				4								
8	1	4	5	2			3									
9	3	2	4	1				5								
10	1	4	3	2				5								
11	1		5	2	3		4									
12	1		4	5	2			3								
13	2	4	3	1				5								
14	1		5	2	4			3								
15	1	3	5	2				4								
16	1	5	4	2		3										
17	1	3		2	5			4								
18	2		3	1	4			5								
19	1		4	3	5			2								
20	2		3	1				4				5				
21	1	3	5	2				4								
22	2	3		1				4				5				
23	2	5	3	1				4								
24	1	4	5	2				3								
25	2	5	3	1				4								
26	2	5	3	1				4								
27	1	5	4	2				3								
28	1		3	2	5			4								
29	2	5			3						4					1
30	3	4	2	5												1

Table III-5. Continued.

Incubation, 26 April - 23 May 1979																
Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2	4	3							5					
2	2	3	5	1				4								
3	1	3		4	2			5								
4	1	5		2		4		3								
5	1	3	5			4		2								
6	1	3		4	2	5										
7		4			3	2			4				5			
8	2	3	4	1				4				5				
9	3	1		2		5										
10	2	3	5	1												
11	1			2	4		3				5					
12	1	5		2	3	4										
13	2		4	1		5		3								
14	2	3		1	4		5									
15	1	3		2		4		5								
16	1			2				4	5							
17	1	3		2	4								5			
18	2		3	1	4			5								
19	1				3		4			2	5					
20	2		3	1				5				4				
21	1	3		2									4		5	
22	2	3		1	4				5							
23	2	4	3	1					5							
24	1	4	3	2				5								
25	2		3	1				4						5		
26	2		3	1				4							5	
27	1		3	2	5	4										
28	1		3	2	5						4					
29	2	4			3						5					1
30	2	4	5	5												1

Table III-5. Continued.

Brood-rearing, 24 May - 1 July 1979

Type	BRTE	POBU	FEBR	TAAS	POSA	ELCI	ARLO	ERCI	SIAL	LEPE	AMAR	TRDU	PHAC	MACA	AMTE	AGCR
1	1	2	4	3				5								
2	2	3		1		5			4							
3	1	3	5	4	2											
4	1			2	5	3	4									
5	1		5	2	4	3										
6	1	3	4	2	5											
7	1	3			4	2				5						
8	1	3		2				5				4				
9	2	3	4	1											5	
10	2	3	4	1		5										
11	1			2	4	5	3									
12	1			2		3	4				5					
13	2	5	3	1			4									
14	2	4		1	3							5				
15	1		4	2	5	3										
16	1			2				3	4						5	
17	1	4		2	5				3							
18	2	3		1	4			5								
19	1			4			2		3	5						
20	1		4	2			5					3				
21	1	3	4	2					5							
22	2	3		1		4		5								
23	1	5	3	2					4							
24	1			2				5		4		3				
25	2		3	1			4			5						
26	2		3	1						5	4					
27	1		3	2					4			5				
28	1		3	2	5				4							
29	2	3			4						5					1
30	2	5	3	4												1

species steadily decreased as the season progressed and cheatgrass brome or medusahad wildrye eventually dominated these areas. In 1979, bulbous bluegrass dominated vegetation type 9 during pre-laying and incubation periods and was of substantial importance in the areas it dominated in 1978.

Six weeks fescue was an important component of the vegetation on the BCPU in 1978 and 1979, but was not an important species in 1977, most likely because of the severe drought conditions which inhibited the germination of this annual, cool season grass. This species dominated vegetation type 18 during the pre-laying period 1978 and was an important component in many other vegetation types throughout 1978. Six weeks fescue was the second most important species in six vegetation types at times during the 1978 season. It's importance decreased on types 5, 6 and 10 as the season progressed, and varied between second and third in importance on type 25. This species increased in importance on type 27 and remained the second most important species throughout the 1978 breeding season on type 28. Six weeks fescue did not dominate any vegetation type during the 1979 season, however, it was the second most important species on five types during that season. This species was most important during the early periods of the 1979 season and decreased in importance in all types in which it occurred as the season progressed.

Storksbill was an important component of BCPU vegetation during 1978 and 1979 but was not an important species in 1977. Its absence in 1977 was most likely because of the drought conditions. This species dominated vegetation types 12 and 19 during the pre-laying period and vegetation type 3 during the laying period in 1978. It was the second most important species in types 3, 13, 19, 21 at times during 1978. Its importance generally decreased in all types in which it occurred as the season progressed. Storksbill dominated only vegetation type 12 during the pre-laying period 1979. It was, however, the second most important species occurring on types 2, 5, 7, 13, 19 and 21 during the early periods of the 1979 breeding season.

Crested wheatgrass (Agropyron cristatum) was the only perennial grass species which dominated any vegetation type on the BCPU. This species had been planted in several areas across the BCPU as a stable forage base for livestock (Fig. III-4). Its importance in these areas was variable, depending upon survival since seeding. Vegetation types 29 and 30 were dominated by crested wheatgrass throughout this study. It also occurred as small relict stands in several of the 30 vegetation types (1, 3, 4, 8, 9, 10, 11, 12) where the importance of this species was eclipsed by the importance of cool season annual grasses. The importance of crested wheatgrass varied throughout the 1978 and 1979 breeding seasons because of variation in the relative importance of other species rather than because of increases or decreases in the abundance of this species.

Numerous other plant species were important components of BCPU vegetation at times during the curlew breeding season. Most of these species were either warm or cool season perennial grasses or warm season forbs.

Giant wildrye (Elymus cinereus) was one of the top five most important species in most vegetation types during 1977 when it was a very conspicuous component of the vegetative strata because the growth of most of the other plant species was inhibited by drought. This inhibition of the other species

decreased their importance in relation to this tall perennial. Giant wildrye's lower relative importance values during 1978 and 1979 were due to increased relative importance values in other plant species as a result of an increase in available moisture and not due to a decrease in giant wildrye. Red threeawn (Aristida longiseta) was another important perennial grass. Although not one of the most important species during 1977, its importance increased markedly in 1978 and 1979, however this was probably due to the nature of our sampling procedure.

Forb species made up a substantial proportion of the BCPU vegetation during the latter periods of the curlew breeding season. Only the most hardy of the warm season forbs were of any importance during 1977: Idaho phlox (Phlox aculeata), yellow salsify (Tragopogon dubius) and common ragweed (Ambrosia artemissifolia). A greater number of forb species was recorded during 1978 and 1979 than in 1977 indicating that many of these species were very sensitive to annual moisture conditions.

There was a seasonal progression in the importance of these forbs which was similar in 1978 and 1979. Idaho phlox became important first, during the pre-laying period and it remained somewhat important throughout the breeding season in many areas. Tumblemustard (Sisymbrium altissimum), and yellow salisfy began to become important components of the vegetation during the laying period and increased in importance in a large number of vegetation types through the brood-rearing period. Common ragweed, tesselate fiddleneck (Amsinkia tessellata), clasping pepperweed (Lepidium perfoliation) and hoary aster (Machaeranthera canescens) all began to become important components of the vegetation during the incubation period and all increased in importance through the brood rearing period. These forbs became important components of the vegetation in types 14, 16, 19, 20, 24, 26 and 27.

Few woody plant species occurred on the BCPU. Big sagebrush (Artemisia tridentata) was by far the most important of these species. Antelope bitterbrush (Purshia tridentata) and low sagebrush (Artemisia arbuscula) followed in importance. These species occurred in small relict stands on vegetation types primarily east of interstate I-84 (Fig. III-4). Vegetation types 23, 24 and 25 supported the most extensive stands of sagebrush on the BCPU. Antelope bitterbrush was most important on vegetation type 22. Because of its growth form we considered Idaho phlox a forb rather than a woody plant.

Height of Vegetation on the BCPU

The BCPU rangeland was characterized by short vegetation. Vegetation height varied spatially within seasons, and between seasons within each vegetation type on the BCPU and it also varied between types.

Several vegetation types were characterized by very short vegetation, while some types supported relatively tall stands (Appendix Table III-1). There was a significant difference in the mean height of vegetation amongst the 30 types within each period of the breeding seasons 1977 to 1979. Vegetation was shortest during brood-rearing 1977 and during pre-laying and laying 1978. There was no significant difference in mean height on vegetation types between these periods.

Vegetation height steadily increased on all types as the 1978 season progressed. Although there was no significant difference in mean height of vegetation between the pre-laying and laying periods 1978, there was a significant difference in mean height of vegetation between laying and incubation as well as incubation and brood-rearing.

All vegetation types supported the tallest vegetation during the brood-rearing period 1978. Mean vegetation height was significantly taller on all types during this period than during any other period throughout the course of the study. Mean vegetation height was significantly much taller in pre-laying 1979 than pre-laying 1978. Vegetation was significantly shorter during laying 1979 than any other period that year but it was not significantly different than brood-rearing 1977 or pre-laying or laying 1978. There was no significant difference between mean height of vegetation between incubation 1978 and incubation 1979, however, vegetation was significantly shorter during incubation 1979 than brood-rearing 1979.

Vertical Coverage of Vegetation

Vertical coverage of vegetation also varied in a number of ways on the BCPU, it varied within seasons and between seasons, and it also varied between types. At times some vegetation types were characterized by low vertical coverage while some types supported thicker stands. Vertical coverage values depended on vegetation height and therefore the patter of variation was similar to the pattern of variation of the height parameter. The importance of vertical coverage to curlews is discussed in the section on use and non-use.

Above Ground Productivity of Vegetation

The BCPU supported a subtantial amount of above ground vegetative biomass during the late portions of the curlew breeding season in most years (Table III-6). The BCPU as an entire unit supported 30.0 grams of above ground vegetative biomass per 0.10 m^2 in June and July 1978 and 28.6 grams per 0.10 m^2 in 1979. There was no significant difference between these years. Furthermore, there were not significant differences in biomass between 1978 and 1979 for any of the 30 different vegetation types.

Plant species on the BCPU are generally at their maximum coverage, density, and frequency during June and July. Very few of the 0.10 m^2 frames which vegetative biomass was removed ever enclosed plots with less than 60% coverage during this period and most approached 100% coverage. Density and species frequency varied from type to type, but most types were dominated by cheatgrass brome or medusahead wildrye at this time. These dominants were very similar in growth form and hence in coverage and density. A random sample of the productivity during the late portion of the breeding season then yielded an estimate of the productivity of these dominants. There was no significant difference between types or between years 1978 and 1979 in the amount of cheatgrass brome or medusahead wildrye when measured as above ground biomass.

Effects of Disturbance on BCPU Vegetation

BCPU vegetation structure was continuously altered by numerous

Table III-6. Mean grams of vegetation biomass per 0.10 m^2 for each vegetation type 1978 and 1979, n = 24 for each vegetation type.

	1978		1979	
Type	$\bar{X}$	Sd	$\bar{X}$	Sd
1	25.4	7.8	23.2	8.5
2	26.1	10.3	22.8	11.4
3	27.8	11.5	29.4	12.4
4	30.9	8.7	35.4	7.5
5	25.5	9.2	24.5	10.4
6	31.1	8.5	30.4	17.4
7	27.2	10.8	29.2	11.5
8	26.3	16.4	22.5	12.8
9	27.9	12.2	27.4	11.5
10	28.2	13.1	30.5	10.4
11	29.4	10.1	24.5	10.8
12	32.7	10.8	29.1	16.4
13	28.0	8.5	24.2	16.0
14	25.2	7.4	29.5	12.5
15	27.2	16.2	26.4	15.0
16	29.9	12.8	27.4	17.1
17	30.0	4.2	26.5	8.2
18	34.0	14.2	31.2	11.4
19	33.5	11.5	34.5	10.8
20	36.3	16.2	31.2	9.8
21	33.6	15.1	32.5	13.1
22	30.1	12.4	29.2	11.2
23	30.2	12.5	28.5	10.4
24	31.4	13.2	30.4	10.5
25	31.1	8.5	31.2	13.1
26	35.9	16.4	30.4	9.4
27	30.4	6.1	27.4	12.1
28	27.4	8.4	24.2	12.8
29	31.6	10.8	30.0	10.0
30	36.2	7.5	34.2	8.9

disturbances. Because disturbances and the effects of the disturbances on the vegetation overlap, it was difficult to tease out the cause and effect relationships. Disturbances responsible for a particular characteristic may have occurred long ago making it difficult to relate the characteristic to its causation. The potential for reporting spurious relationships was great because some effects were long-lasting and disturbances were frequent if not continuous. The co-occurrence of variation in vegetation structure and disturbance may not be enough to imply a relationship.

Grazing by sheep, cattle and grasshoppers and fire appeared to be the most influential disturbances on the BCPU vegetation. These disturbances affected vegetation by altering the species composition, height and vertical coverage. The magnitude of change which occurred as a result of these disturbances was dependent on the intensity or extent of the disturbance and the time of year in which the alteration takes place (see the later section on Disturbance).

The vegetation on the BCPU was continuously changing. Because the factors effecting this change act continuously on the vegetation, species composition and the physical stature of this strata will never be the same in any two evaluations.

EFFECTS OF GRAZING ON CURLEWS

Public land on the BCPU has been used historically for livestock grazing. We identified 20 management units each of which has its own grazing regime. Seventeen of these areas were included in the grazing analysis. Four of these areas received spring and late fall grazing by sheep each year. Two areas were grazed exclusively by cattle mainly during the spring and late fall of each year. Eleven areas are incorporated into one 3-pasture and two 4-pasture rest-rotation cattle grazing systems. These pastures are used mainly in the winter and spring (Fig. III-5).

Sheep bands trail across the BCPU rangeland under permits issued operators for specific routes through the BCPU (stock driveways, Fig. III-6). The stock driveways average 0.4 km wide and vary from 16.9 to 41.8 km long. Three of the four routes are used in both spring and fall, but the fourth trail is used only in the fall. Permits are issued to trail 31,000 sheep on BCPU stock driveways each spring. Only bands of ewes and lambs are driven over stock driveways. Because lambs are not counted on trailing permits and there are approximately 1.3 lambs per ewe a total of 71,300 ewes and lambs are allowed to trail the BCPU. Band sizes range from 2,300 to 3,000 head and average 2,700 head. Approximately 32,600 sheep are permitted on BCPU stock driveways in the fall. Stock driveways used for the trailing of sheep each spring and fall cross seven of the rest-rotation treatment areas used by cattle, hence those treatments receive common-use (Fig. III-5).

Boise District Office of the BLM supplied data concerning grazing and livestock management on the BCPU (Tables III-7,8). These data were taken directly from official billings for use of public lands on the BCPU and cognate records on file at the Boise District Office, BLM.

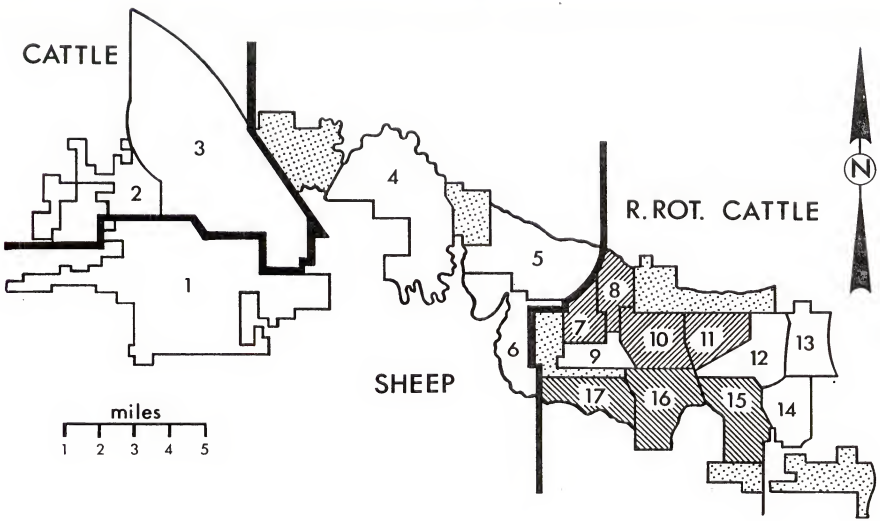


Fig. III-5: Location and extent of 17 grazing treatment areas on the BCPU during 1977-79. The stipled areas were omitted from the analysis, the cross-hatched areas receive common-use by sheep and cattle; areas 15, 16 and 17 receive common-use in the spring and fall and areas 7, 8, 10 and 11 receive common-use only in the fall.

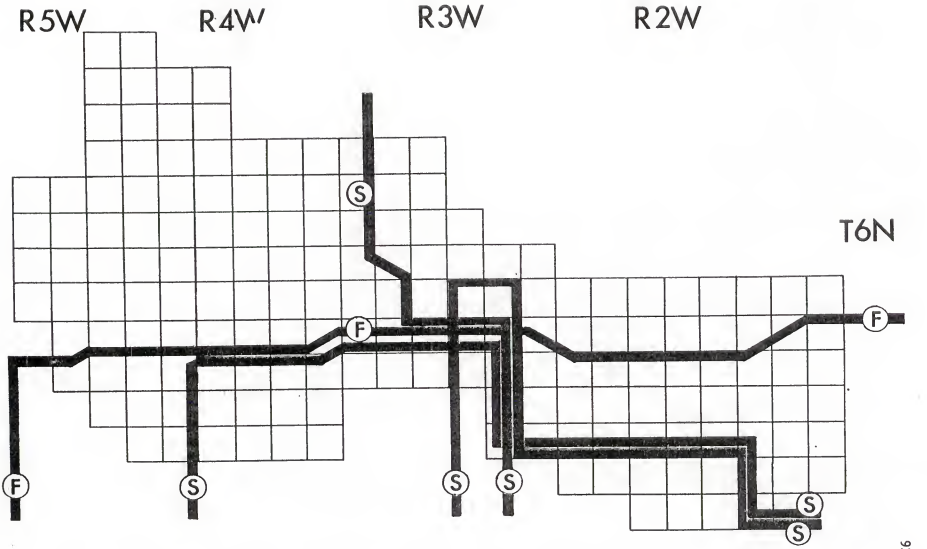


Fig. III-6: Sheep trail routes across the BCPU. Spring and fall use routes are designated "S". The one route used only in the fall is designated "F".

Table III-7. Size of treatment area, kind of use, number of livestock and AUMs on spring-fall sheep and cattle areas for each year 1977, 1978 and 1979.

Treatment area	Hectares of rangeland	Kind of use	Spring-use		Fall-use	
			No.[a]	AUMs	No.[a]	AUMs
1	4129	Sheep	11,500	1132	6,400	260
2[b]	972	Cattle	225	225	225	225
3	4412	Cattle	450	939	358	859
4	1922	Sheep	40,500	498	18,400	309
5	1376	Sheep	2,400	280	1,800	216
6	899	Sheep	41,400	174	18,800	125

[a] No. refers to the number of head of livestock grazed on the treatment area. Spring is from 1 March to 20 June; fall is from 1 November to 31 January.

[b] A portion of this grazing use (173 AUM's) in this area occurs from 21 June to 31 October. The AUM's were included in the spring-use AUM's.

Table III-8. Size of treatment area, kind of use, number of cattle and AUMs on rest-rotation and common-use treatment areas for each year 1977, 1978 and 1979. Spring is from 1 March to 28 June; winter is from 14 November to 28 February.

Treatment		1977				1978				1979			
		Spring		Winter		Spring		Winter		Spring		Winter	
Area	Hectares	No.	Aums	No.	Aums	No.	Aums	No.	Aums	No.	Aums	No.	Aums
7	520	0	0	267	508	333	737	0	0	0	0	0	0
8	480	100	80	0	0	0	0	0	0	346	669	58	106
9	455	352	428	0	0	0	0	0	0	0	0	0	0
10	774	0	0	0	0	505	1579	0	0	0	0	455	534
11	621	0	0	238	452	238	80	0	0	0	0	0	0
12	772	555	246	561	493	0	0	485	228	485	198	295	664
13	677	555	739	0	0	0	0	0	0	480	849	575	503
14	690	0	0	510	307	510	186	0	0	0	0	0	0
15	950	0	0	0	0	510	1283	132	189	0	0	450	596
16	870	616	496	0	0	0	0	0	0	395	918	0	0
17	648	616	715	0	0	0	0	595	119	595	629	300	433

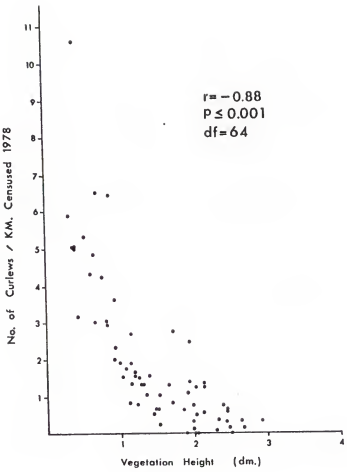
Results

Curlews established breeding territories on specific portions of the available rangeland. Number of curlews observed per kilometer surveyed in each of the management units was positively correlated with the size of the areas ($r_s = 0.81$, $p \leq 0.01$, $N = 17$; Spearman rank correlation coeficient). Curlews also used portions of the BCPU characterized by short, low profile vegetation. The numbers of curlews observed per kilometer in each of the 17 management units was significantly negatively correlated with the mean vegetation height in each of the management units during the pre-laying and laying periods of 1978 and 1979 (1978: $r_s = 0.59$, $p \leq 0.01$, $N = 17$; 1979: $r_s = 0.52$, $p \leq 0.05$, $N = 17$). The same relationship between curlew numbers and vegetation height exists on a finer grain of analysis. The number of curlews observed per kilometer traveled was significantly, negatively correlated with the mean vegetation height in each section during the pre-laying and laying periods of both the 1978 and 1979 breeding seasons (Fig. III-7). Similarily, curlew numbers were significantly negatively correlated with the mean percent vertical coverage of vegetation in each section during pre-laying and laying in 1978 and 1979 (Fig. III-8).

Curlews located their breeding activities in areas which had been recently grazed by livestock and were characterized by short, low profile vegetation. We never observed breeding curlews in areas of rangeland which had not been grazed by livestock sometime within the preceeding 12 months. In addition, the number of curlews observed per kilometer in each management unit during pre-laying periods 1978 and 1979 was significantly, positively correlated with the annual total number of AUMs (animal unit months) (1978: $r_s = 0.58$, $p \leq 0.01$, $N = 17$; 1979: $r_s = 0.51$, $p < 0.05$, $N = 17$).

In general, mean vegetation height in all treatment units increased from early spring through midsummer each year regardless of grazing regime (Fig. III-9). Although vegetation height and density in March depended on the characterstics of the vegetation at the end of the previous growing season, vegetation was usually shorter in March than in mid-August of the year before. The 1977 growing season was characterized by the most severe drought in the area in the past 64 years. The vegetation was so sparse at the end of the growing season that fall grazing had no measurable impact on it. The 1978 growing season was characterized by a tall, dense stand of annual grasses and forbs by midsummer because it was an unusually wet spring. Although the BCPU rangeland retained a large amount of this growth in spring 1979, fall grazing had an important impact on spring range condition. Fall 1978 grazing intensities were significantly negatively correlated with mean vegetation height in treatment areas during pre-laying and laying 1979 ($r_s = -0.54$, $p < 0.05$, $N = 17$). Grazing intensity (acres/AUMs) accounted for most of the variability in mean vegetation height between treatment areas and in the number of hectares of vegetation less than 1.0 dm tall.

However, in both years management units grazed exclusively by sheep or by sheep and cattle contained more short vegetation (32% of the area sampled) than units grazed exclusively by cattle (19% of the area sampled). Treatment areas grazed exclusively by sheep contain proportionately more hectares of



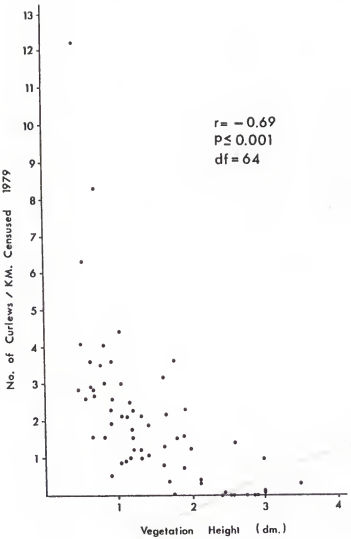


Fig. III-7: Mean number of curlews observed per kilometer censused and mean vegetation height in sections of the BCPU were significantly, negatively correlated during pre-laying and laying periods 1978 (left) and 1979 (right). These data fit the exponential regression better than linear power or logarithmic regressions.

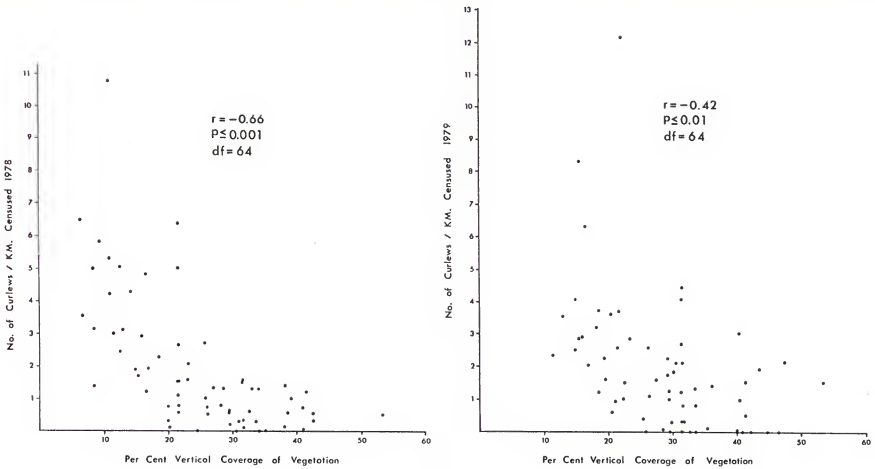


Fig. III-8: Mean number of curlews observed per kilometer censused and mean percent vertical coverage of vegetation in sections of the BCPU were significantly, negatively correlated during prelaying and laying periods 1978 (left) and (1979) right. These data fit the exponential regression better than linear, power or logarithmic regressions.

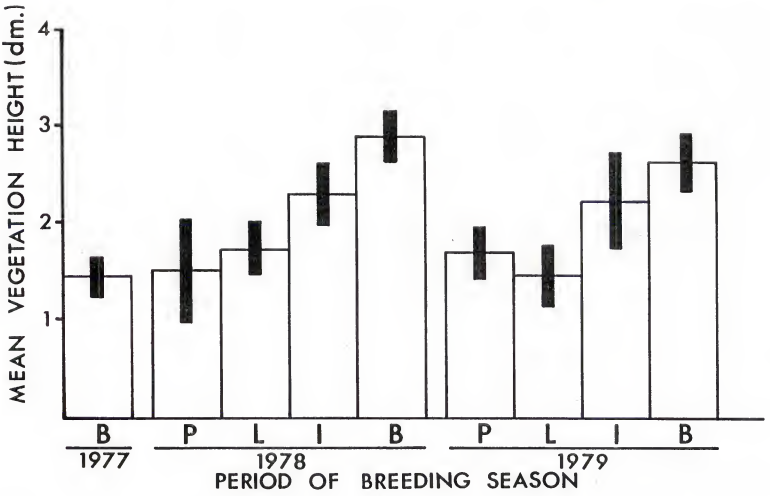


Fig. III-9: Vegetation height ($\bar{x}$ and s.d.) for each period of the breeding season 1977-1979. P = pre-laying, L = laying, I = incubation and B = brood-rearing (N = 1360 for each period).

short (< 1 dm) low profile vegetation than treatment areas grazed exclusively by cattle (Table III-9). Numbers of curlews observed per kilometer surveyed were significantly positively correlated with numbers of hectares of vegetation less than 1 decimeter tall during the pre-laying and laying period 1978 and 1979 (Table III-9). Number of hectares of vegetation less than one decimeter tall during pre-laying and laying periods 1978 and 1979 in all treatment areas was significantly, positively correlated with spring grazing intensity and stocking rate (Table III-9).

Discussion

Long-billed curlews using the BCPU during the early portion of their breeding season were most likely to be found on large expanses of rangeland. Breeding curlews were territorial and required a minimum amount of land to initiate land tenure and other breeding activities. Territories averaged 14 ha in the most densely populated part of the BCPU. Curlews did not establish territories adjacent to unsuitable habitat, but left an unoccupied "buffer zone" 300-500 m wide around the edge. Because of the buffer zone effects an area must be at least three times as wide as curlew territory before it will be accepted as a territory.

Curlews also required short vegetation. Any grazing of the BCPU during the fall or very early in the pre-laying period of the curlew breeding phenology reduced the height of the vegetation. Fall grazing of the BCPU in 1977 was unnecessary for the establishment of short vegetation in 1978 because of the 1977 drought. Spring 1978 grazing maintained short vegetation height through the early portion of the breeding season. Fall 1978 and spring 1979 grazing produced fewer hectares of preferred habitat than the year before because of the increased vegetative productivity of the 1978 growing season.

All livestock grazing on the BCPU had the effect of reducing vegetation height in areas dominated by annual grasses and forbs. However, neither cattle nor sheep were able to graze even modestly dense stands of perennial bunchgrasses such as crested wheatgrass down to a height that was acceptable to the curlews for nesting.

Sheep were introduced onto management units at much higher stocking rates than cattle and density of grazing sheep was substantially greater than cattle density. In addition, bands of sheep grazed in a broad front and were actively driven over wide swaths of rangeland when they are trailed to better forage. Bands of sheep effectively broke up dense stands of standing dead vegetation as they grazed or trailed by riving this material to a size that could be dispersed by wind and/or incorporated into the soil. The net effect was vegetation of low profile composed primarily of current years growth.

The relationship between sheep and curlew use was different than the relationship between cattle and curlew use. Cattle tended to travel over established paths rather than produce new ones through the standing dead vegetation. Cattle took longer to trample large areas of standing dead vegetation than sheep and were therefore not as effective in producing preferred curlew habitat within the early periods of curlew breeding phenology. Curlew density was much greater in treatment areas grazed

Table III-9. Number of hectares of vegetation less than 1 decimeter tall in treatment areas was significantly correlated with the number of curlews observed/kilometer censused, spring grazing intensity and spring stocking rates.

Vegetation <1 dm (Ha) correlated with	Year	r	p≤	N
No. of curlews/kilometer censused	1978	0.82	0.01	17
	1979	0.64	0.05	17
Spring grazing intensity (acres/AUM) in treatment areas	1978	0.45	0.05	17
	1979	0.52	0.05	17
Spring stocking rate (No. head grazed)	1978	0.76	0.01	17
	1979	0.58	0.05	17

exclusively by sheep or which received common-use than areas grazed exclusively by cattle.

Within the eleven treatment areas that make up the rest-rotation system, the treatment areas which received common-use supported the greatest number of curlews, regardless of the year or cattle grazing pattern. Curlews did not exhibit a numerical increase within treatments which had been grazed by cattle during the spring or preceeding fall 1977, 78 or 79. Several factors were responsible for this lack of relationship between the cattle grazing regime within the rest-rotation system and the density of curlews using the various rest-rotation treatment areas.

If any relationship between curlew use and cattle use of the rest-rotation treatment areas exists, it was eclipsed by common use grazing regime on seven of the eleven treatment areas. In addition some treatment areas contained large portions of land that are unsuitable for curlew breeding because of very choppy topography, dense crested wheatgrass plantations, dense sagebrush stands or close proximity to human disturbance (primarily residences). For a proper analysis of the rest-rotation systems effects on breeding curlew ecology and behavior we would have to eliminate all areas which contained these factors; leaving very little land and data to represent this very large complex system. The probability of misrepresenting the effects of this grazing system on curlew use was too great to attempt this kind of analysis. However, curlews attempt to breed on large expanses of rangeland characterized by short vegetation and the rest-rotation system of cattle grazing has the potential and to a great extent does produce suitable curlew-habitat, as does the deferred-rotation system on treatment area three.

Any grazing regime that reduces vegetative height and density to minimum values at the beginning of the nesting cycle will be beneficial to curlews. Year-long grazing is the least helpful. Rotation and deferrment systems have the potential to produce suitable curlew habitat but resting pasture so that vegetative cover is heavy during March, April and May would be detrimental. Because of year-to-year variation in climatic factors and great variation in the relative lushness of the vegetation no single grazing regime can be equally beneficial for curlews in all years. For example, after an especially good growing season it would be helpful if grazing could be increased significantly in order to remove the standing vegetation before the curlews return the following spring.

DISTURBANCE

The BCPU rangeland is subject to frequent disturbances including fire, vehicle travel on roads and trails, off-road travel, urban conversion, and the direct human disturbances associated with each of these activities in addition to the grazing and livestock trailing already discussed. These types of disturbances all have profound effects on the vegetative characteristics of the rangeland and therefore they affect Long-billed Curlew distribution and breeding density. Many of these disturbances also have direct negative effects on curlew reproductive success.

Fire

The BCPU annually accumulates a thick layer of plant biomass which in the late summer creates a fire hazard. Since 1955, approximately 44,000 acres of rangeland vegetation have burned on the BCPU (Fig. III-10). Approximately 85 percent of all fires on the BCPU, since 1955, have been the result of human activities (Table III-10).

Fire has various effects on the plant community of the BCPU and on curlew behavior and distribution depending on the location of the fire, the extent of the burn, the time of year, soil moisture conditions, and climatic condition following the fire. Fires are generally retrogressive in their effects and return areas to earlier seral stages of succession. On the BCPU the process of retrogression is initiated by the removal of the vast majority of flammable plant biomass during the burn. This yields a substrate denuded of standing vegetation except for occasional sagebrush branches, tall forb stems and bases of perennial grasses.

In 1979, we measured the succession of revegetation on three burns which occurred in the fall 1978 (Fig. III-11). During the pre-laying and laying periods of the curlew breeding cycle, the three burns were dominated by cool season grasses and forbs (Table III-11). The top dominant plant species was cheatgrass brome. However, as the season progressed, the cool season plants surrendered their dominance (discussed below) to the warm season forbs, tumblemustard (Sisymbrium altissimum) and prickly lettuce (Lactuca serriola) (Table III-11). Cheatgrass brome maintained a high importance in the vegetative composition throughout the curlew breeding season and created an understory of dense plant biomass.

By the brood-rearing period, the warm season forbs towered over the cheatgrass understory producing a tall, thick, layered vegetative condition on the lower Homestead burn (Fig. III-12). Grazing modified the formation of this layered vegetation on the Little Freezeout and upper Homestead burns, burns C and B (Fig. III-12). The lower Homestead burn was grazed by cattle early in the pre-laying period, but the livestock were removed prior to the period of lush vegetation growth and this burn remained ungrazed through the curlew breeding cycle. Lower Homestead burn had significantly taller vegetation than the grazed burns as well as substanitally more vertical cover (Figs. III-12, 13 and Appendix Table III-2). The vegetation structure which occurs following a fall burn is dependent on the climatic conditions and vegetative structure of the previous year and the climate and disturbances of the present growing season as well as the amount and pattern of reseeding. The vegetation structure characterizing the 1979 regeneration of the lower Homestead burn was a result of; 1) an abundance of warm season forb seeds produced in the uncharacteristically wet 1978 growing season, 2) excellent reseeding of the burn because of its location, 3) the very limited growth and density of cool weather grasses early in 1979, 4) the late rainfall of 1979, and 5) the absence of grazing after the warm season forbs began to grow. Late season grazing on the other two burns reduced the importance of the warm season forbs.

Fire altered the local physical characteristics of vegetation which affected curlew breeding attempts. During the pre-laying and laying periods of the curlew b reeding cycle, portions of the three 1978 burns were used as

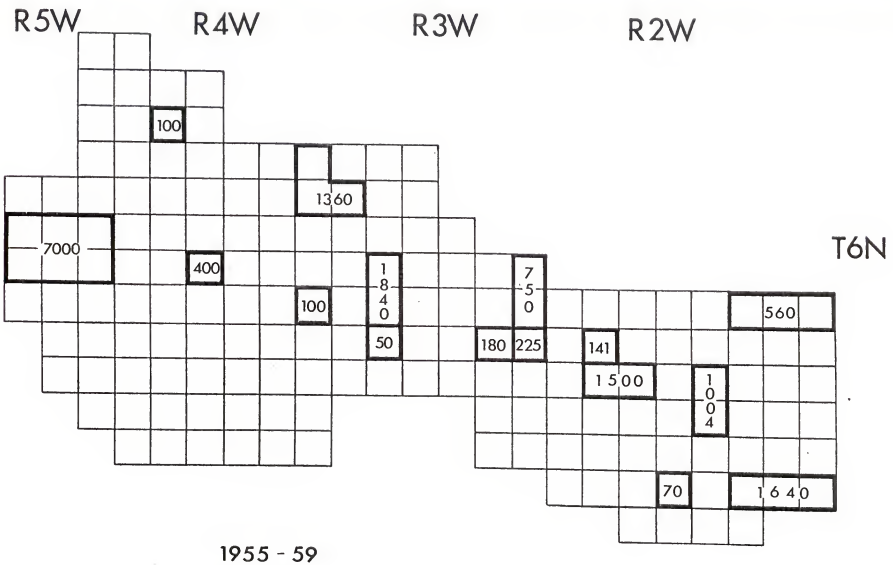


Fig. III-10: Number of hectares burned per section, 1955-1979, by 5-year periods (1 ha equals approximately 2.5 acres). Some areas burned more than once during a single 5-year period.

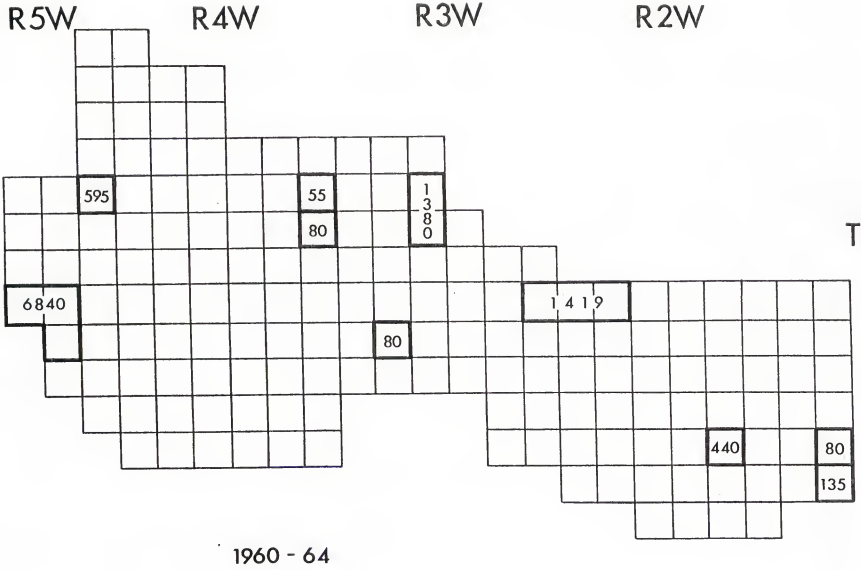
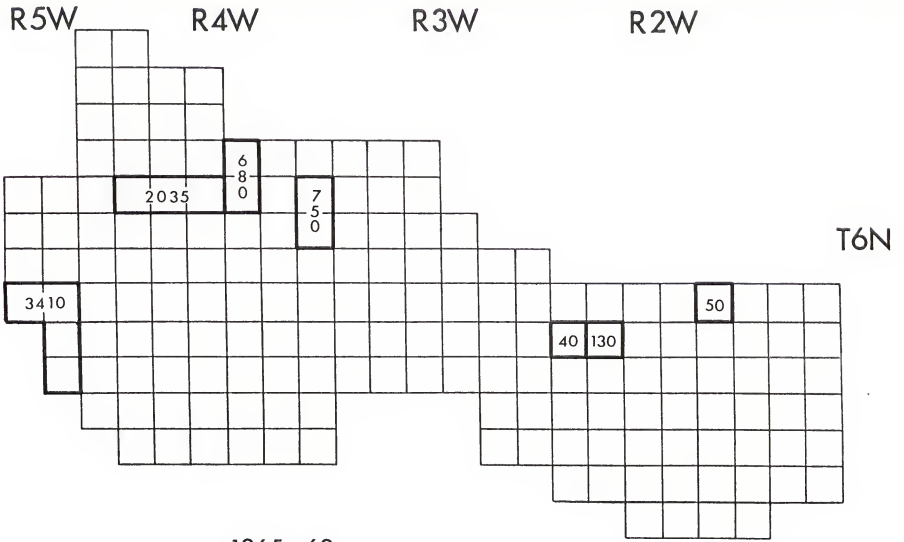


Fig. III-10: Continued.



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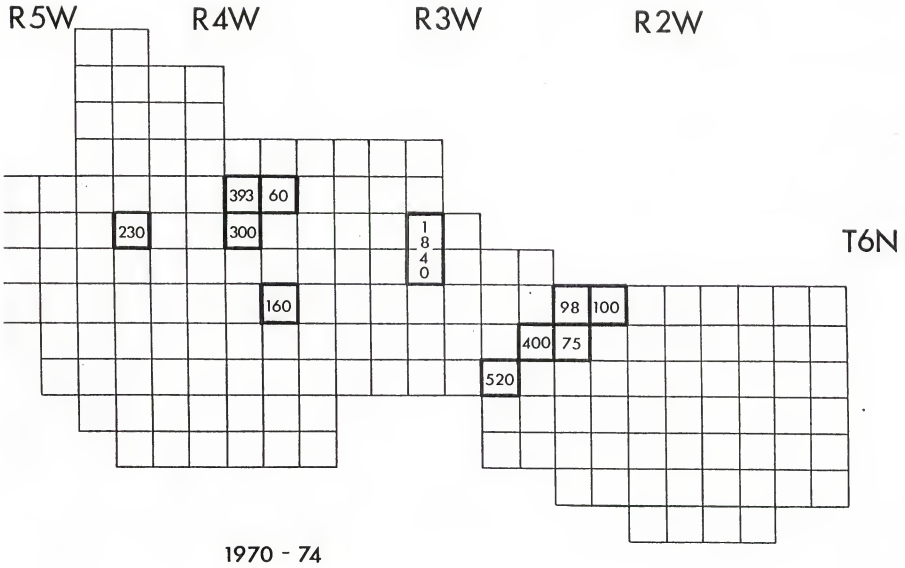

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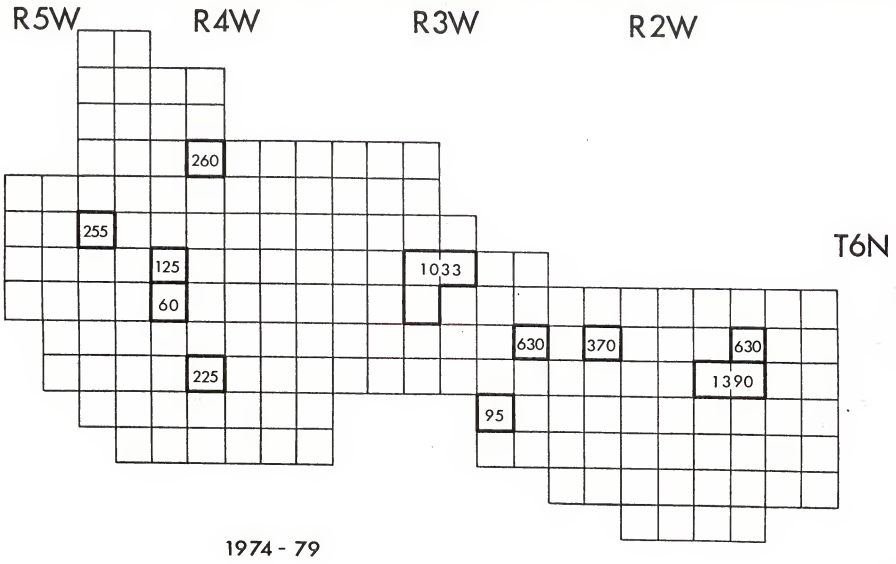


Fig. III-10: Continued.

Table III-10. Probable causes of 215 fires on the BCPU, 1955-1979 (data from the Boise District Office, BLM).

Cause of Fire	Number of Fires 1955-1979	Percent
Miscellaneous	53	24.6
Recreation	41	19.1
Lightning	32	14.9
Equipment	19	8.8
Smoking	18	8.4
Railroad	18	8.4
Children	11	5.1
Incendiary	8	3.7
Debris	7	3.2
Utility	4	1.9
Unknown	4	1.9
Total	215	100.0

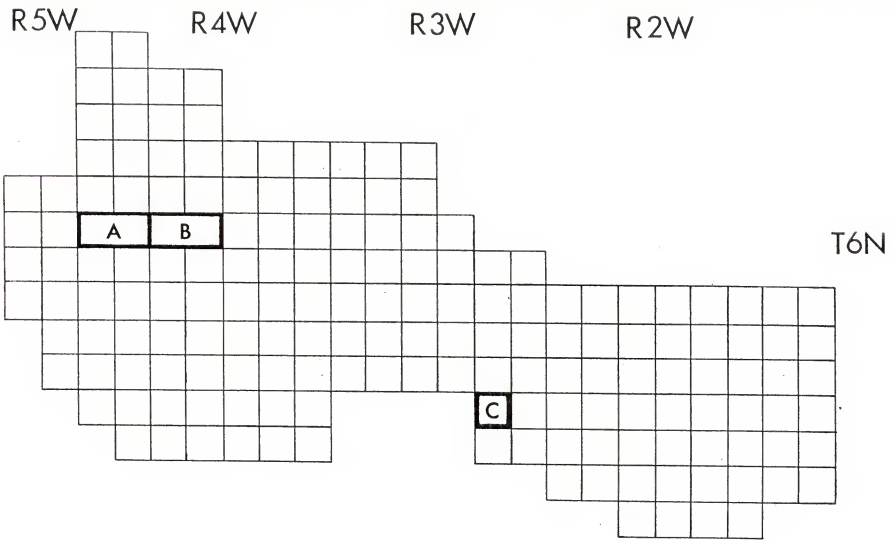


Fig. III-11: Sections in which fall 1978 burns occurred in which revegetation studies were conducted (Table III-11) during 1979: lower and upper Homestead burns (A and B), Little Freezeout burn (C).

Table III-11. Changes in the importance values (IMPV) of the top dominant plants during 1979 on three burns which occurred in the fall of 1978.

Burn	Stage of Breeding	Importance Values							
		BRTE	ERCI	SIAL	POBU	LASE	AMAR	TAAS	POSA
Lower Homestead									
	Pre-laying	141.8	123.4	5.9	16.5	4.2	--	--	--
	Laying	144.9	81.5	34.8	10.4	26.9	--	--	--
	Incubation	82.5	13.4	79.7	31.5	84.8	--	--	--
	Brood-rearing	51.4	10.9	88.8	25.2	129.4	--	--	--
Upper Homestead									
	Pre-Laying	138.5	86.6	29.5	--	--	16.8	--	21.5
	Laying	147.1	89.5	27.4	--	--	21.2	--	17.2
	Incubation	101.4	51.5	41.4	--	--	70.4	--	30.5
	Brood-rearing	68.1	62.5	52.8	--	--	81.5	--	31.4
Little Freezeout									
	Pre-laying	151.5	82.8	11.5	12.9	--	--	40.5	--
	Laying	158.6	68.9	19.8	14.5	--	--	30.8	--
	Incubation	111.4	49.5	70.9	36.2	--	--	31.4	--
	Brood-rearing	64.9	59.5	81.5	41.5	--	--	45.2	--

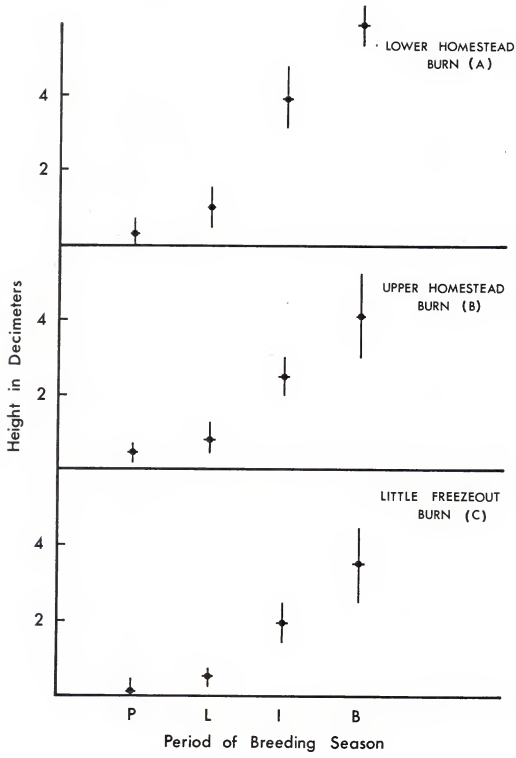


Fig. III-12: Height of vegetation on the three fall 1978 burns, during the 1979 growing season (P = pre-laying, L = laying, I = incubation, and B = brood-rearing periods of the curlew reproductive cycle).

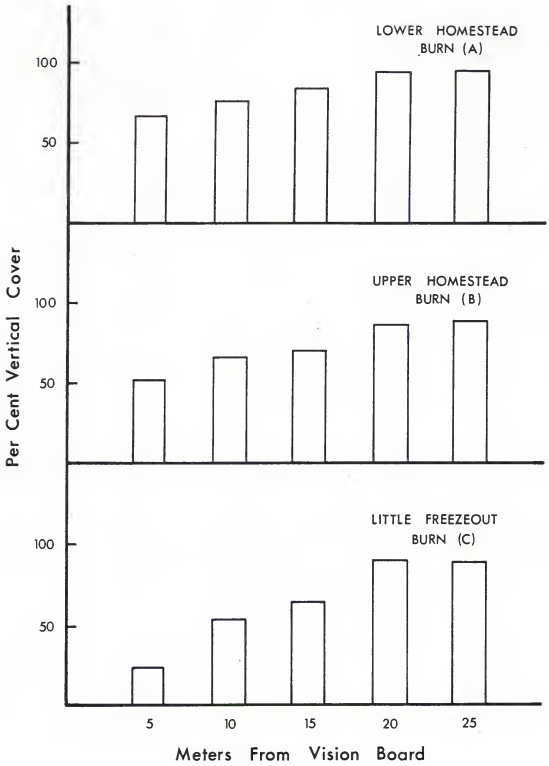


Fig. III-13: Percent vertical cover on the three 1978 fall burns during the 1979 brood-rearing season. Note the much greater percent vertical coverage at 5-15 m distance on the lower Homestead burn. See also Appendix Table III-2.

foraging areas by breeding adults. Part of the lower Homestead burn was defended by a male curlew well into the incubation period. Territorial defense ceased when the vegetation attained a height of about 4 decimeters. This naturally marked male was last seen on the lower Homestead burn on 8 May 1979. We did not observe curlews using this area after this date. Curlews used the upper Homestead and Little Freezeout burns throughout the breeding cycle, primarily to forage.

A late summer or fall burn may result in suitable or even attractive vegetation structure on curlew habitat the following spring. In one case the condition of the resulting habitat was suitable enough to be defended. The post burn succession of plant species and physical structure was rapid, making the burn unsuitable for curlew use. Therefore, fire does not invariably produce curlew habitat. The early periods of the seasonal succession following a fall burn can be used by curlews while the latter periods can produce unsuitable habitat for curlew activities unless it is modified as by grazing. In 1979, the unsuitability of the lower Homestead burn was due to the physical characteristics of the tumblemustard - Prickly lettuce -cheatgrass brome plant association. Tumblemustard attained densities of up to 60 individual plants per square meter and heights of up to 1.0 meter in the relatively wet and late growing season of 1979. Tumblemustard and similarly dense stands of prickly lettuce and cheatgrass brome produced a layer of vegetation virtually impossible to see through from 3 decimeters above the substrate. Although many curlew habitat requirements changed during the breeding cycle, the necessity of short vegetation and low vertical cover remained constant. Fall burning supplied this requisite for a very critical time in the breeding cycle, but it did not maintain the presence of the requisite. Short vegetation and low vertical cover was maintained longer on the upper Homestead burn and Little Freezeout burn than on the lower Homestead burn by grazing and allowed for the continuous use of these two burns by curlews throughout the breeding cycle.

If the spring of 1979 had been as dry as the spring of 1977, the warm season forbs would not have germinated and all the burns would have remained curlew habitat. The general suitability of the BCPU for breeding curlews may be partly the result of historic burning. It has been suggested that the original dominant plants in this portion of the Snake River drainage were sagebrush (Artemesia tridentata) and perennial herbs including tall grasses and forbs (Davis 1952). The once wide-spread sagebrush was nearly eliminated, primarily by fire. There was a low degree of correspondence between the present distribution of curlews on the BCPU and areas which have been burned since 1955 (Fig. III-14). This low correspondence suggests that burning by itself is not the primary factor determining where curlews will concentrate their breeding activities.

Off-Road Vehicles (ORV's)

Off-road vehicles pose subtle threats to curlews on the BCPU. ORV use has become more frequent in recent years on the rangeland portion of the BCPU. The rolling topography, homogeneous vegetation structure and immediate accessibility of the BCPU rangeland provided an attractive and challenging area for increasing numbers of 4-wheel drive and motorcycle enthusiasts. Some areas on the BCPU proved to be more attractive than others to ORV users and the majority of ORV use was localized in a few areas (Fig. III-15). The

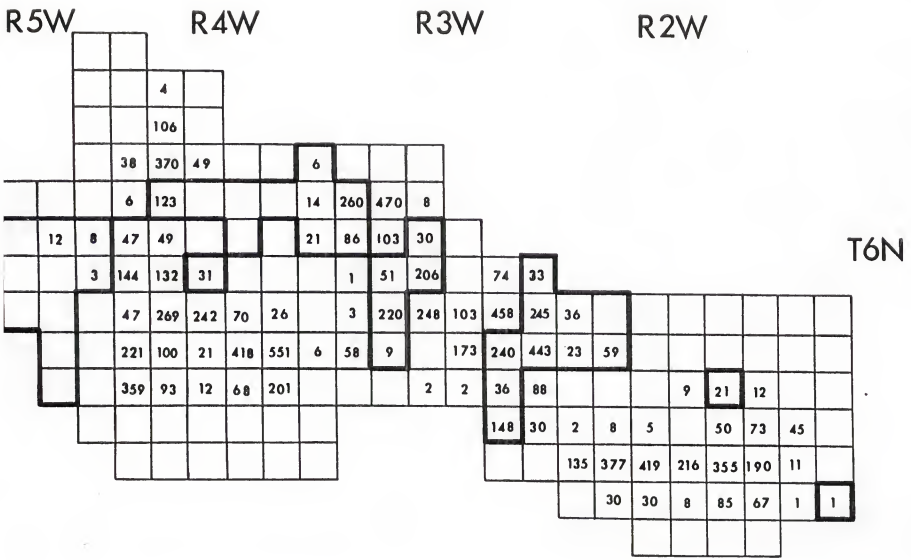


Fig. III-14: Sections in which fires occurred one or more times between 1955 and 1979 (outlined with heavy lines) and numbers of curlew seen during 1977-79.

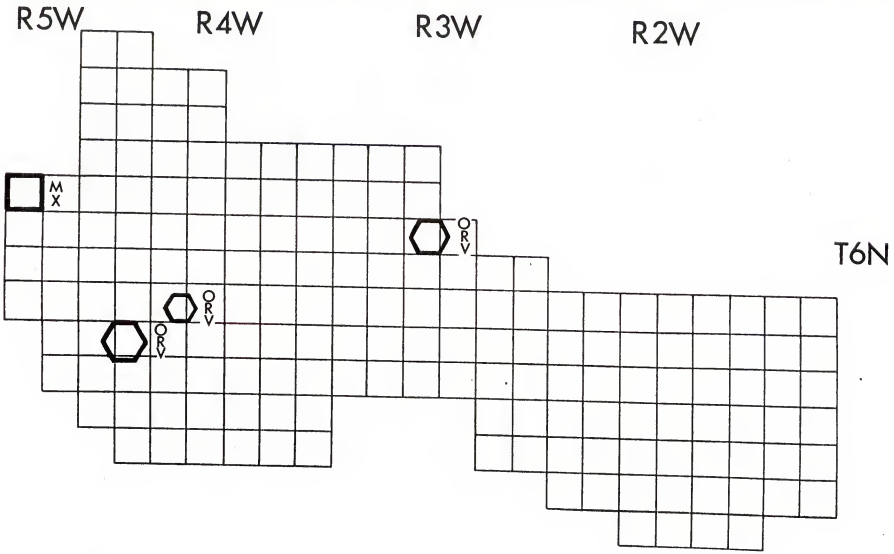


Fig. III-15: Location of a private ORV enterprise (MX) and the three heavily used "ORV Parks" on BLM lands.

observed frequency of ORV's decreased away from these centers of activity. This pattern of ORV use produced a gradient of potential impact on the habitat of the BCPU and on curlew breeding success.

In spring 1979, a private "moto-cross" course was established on the western edge of the BCPU (Fig. III-15). Advertizement of the track drew many more ORV users to the BCPU area than we observed in previous years (Fig. III-16). The area on which the tract was established was apparently no more attractive to motorcycle enthusiasts than many other portions of the BCPU rangeland which were more accessible and more importantly "free". Numerous individuals opted to forgo the price of admission and used the nearby rangelands instead.

The impact of ORV use on the vegetative structure and on curlew behavior and distribution at any one site is the result of interactions between several factors: 1) the location of the site, 2) the extent of ORV trails and roads at that location, 3) the seasonal period of use, 4) the frequency of use, 5) what other human activities are carried on in conjunction with the ORV use, 6) the initial attractiveness of the area to curlews, and 7) the proximity of the area to suitable or preferred curlew habitat.

Unfortunately, the majority of ORV traffic on the BCPU was concentrated in or near areas of high curlew density. Use of ORV's in these areas was frequently restricted to specific slopes and draws and these specific locations received most of the physical modification. Some traffic violated this pattern and invaded the surrounding terrain thereby increasing the area and extent of the impact. This practice creates an insidious problem since the new tracks produced through the vegetation prove attractive to subsequent ORV enthusiasts. ORV travel on very steep slopes and on very wet ground often results in immediate damage to vegetation. Frequent or prolonged use of an area by ORV's can remove vegetation completely. Even one track can completely remove vegetation from a steep slope if the ORV driver spins the tires of the vehicle which is exactly what they usually do. The problem is compounded by erosion particularly on steeper slopes where vegetation is unlikely to be restored. The immediate effects are obvious and the long-term effects are easily predicted; if ORV travel on the BCPU continues to be unrestricted and continues to grow increasingly popular, the value of the unit as rangeland and habitat for wildlife will decrease drastically.

The physical modification of the vegetative structure of the BCPU induced by ORV travel directly influenced curlew behavior and distribution. Curlews were rarely observed on slopes which support frequent ORV travel or which were eroded as a consequence of past damage. However, curlews did use adjacent, undamaged slopes. This differential use of adjacent slopes demonstrates that the slopes damaged by ORV travel are unsuitable for curlew use. Unsuitability is due to the modification of the vegetation structure and also to the periodic and sometimes frequent presence of the drivers and their vehicles.

By plotting on maps what appears to be otherwise suitable curlew habitat we estimate that 413 ha (1,020 acres) have been made unsuitable by ORV use. Areas which are highly altered by ORV traffic are characterized by sizeable patches of land almost denuded of vegetation (Table III-12). Some vegetation was required by curlews during the breeding cycle. The range of tolerable cover is discussed in the section on Seasonal Habitat Use. Vegetation

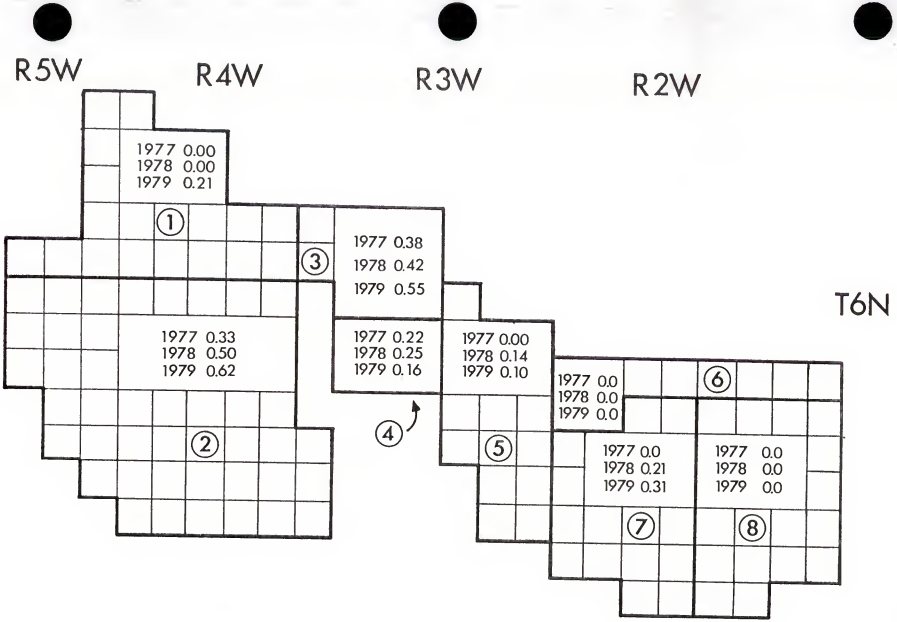


Fig. III-16: Comparison of ORV use, 1977-1979 in the different parts of the BCPU. The figures are average number of ORV's seen per census throughout each season. Trends within each area can be compared across areas.

Table III-12. Approximate amount of land denuded by ORV use. Area designation correspond to areas shown in Fig. III-17.

Area	Approx. ha
1	1 to 3
2	600 to 700
3	320 to 500
4	100 to 120
5	75 to 100
6	40 to 60
7	25 to 30
8	1 to 10

supports the prey base of curlews, supplies a background in which to seek refuge from predators, and may provide requisites to both chicks and adults for thermoregulation. Modification of the vegetation by ORV travel effectively eliminates these requisites from areas, and renders areas valueless to breeding curlews.

ORV traffic can directly affect curlew breeding success. Frequent disturbance close to a nest early in incubation may result in abandonment by the adults. Disturbance may interrupt critical parental behaviors such as brooding or shading. Furthermore there is always the chance of eggs or chicks being run over.

Curlews tolerate occasional minor disturbances at any point in the breeding cycle. The most sensitive periods are the pre-laying and laying portion of the phenology. In 1978, we found a nest (No. 59) situated ten meters from an established jeep trail. On Sunday afternoon (30 April) we observed repeated travel of several motorcycles and an all terrain vehicle within 2 meters of the nest which at that time contained one egg. A clutch of four eggs was completed the following Friday (5 May), and we found the nest abandoned on Saturday (14 May), the eggs having apparently been consumed by magpies. Heavy ORV traffic too close to the nest following clutch completion apparently caused adult desertion. At another nest (No. 72), situated amongst a maze of trails in the Dewey Dump area, we noted fresh ORV tracks within three meters of the nest cup midway through incubation. The eggs from this nest hatched successfully on 2 May, 1978.

Adult curlews responded to ORV's with antipredatory behaviors. These behaviors were most evident early in the brood-rearing period when chicks are being moved about the rangeland. When adult curlews began to "mob" the vehicle the chicks freeze so that movement will not reveal their position to the "predator". During cold windy, wet weather, or on hot, sunny days, this behavior leaves very young chicks vulnerable to exposure. A more important aspect of this type of interaction is that if the family unit is frequently disturbed by the presence of ORV's it will relocate in an area of less disturbance. The group may have to compromise some other aspects of habitat suitability in order to avoid ORV disturbance. This may result in trading ORV for other problems less easily controlled by land managers.

Transportation Network

The BCPU is criss-crossed by a network of vehicle access routes ranging all the way from an interstate highway to two-track jeep trails. Curlew density in a given area was inversely related to the sophistication of roads in that given area. The degree of sophistication of a road was directly related to the density of the human population in an area. Curlew populations were most dense in areas containing only minor access dirt roads.

Minor roads (often no more than two ruts) are established to provide access to areas within the rangeland portion of the BCPU. Some of these are used to provide access for utility equipment along power lines, or natural gas and oil pipelines. However, the majority of the trails were established by ranchers and sheepherders to provide access to portions of range well away from other roads. These trails generally run along the crowns of ridges.

Curlews generally located nesting territories along ridges, and minor access roads run along the crests of many of these ridges. These roads have both detrimental and beneficial affects on curlews with nearby territories. Trails may be detrimental to curlew breeding success in two ways. First, by allowing access to the areas the trails expose the curlews to the spectrum of activities humans may perform while in these areas. Vehicular traffic along dirt trails is generally ignored by curlews. However, during brood-rearing vehicles travelling over trails close to curlew chicks are frequently mobbed by the adults. This behavior ceases once the vehicles have travelled a distance sufficiently far from the chicks. However, the spectacular behavior of the adults mobbing a vehicle tempts the driver to stop and watch the frantic displays of the adults. The interaction is prolonged and this must be stressful to both adult curlews and chicks. Human activities which may ensue after a vehicle is stopped along a trail near curlew breeding activities are discussed in the section: "associated human disturbances".

Dust caused by vehicle traffic along trails and roads may influence curlew breeding success. Four radio-marked chicks from two broods suffered plugged nostrils due to dust apparently raised by vehicles traveling along the county road through the Sand Hollow area during late May and June, 1979. In one brood, one of the chicks survived and fledged (No. 243), its sibling lost its radio and its fate is not known (No. 245). The two chicks from the second brood (Nos. 297 and 298) both perished when four days old. When they were found on day four, both again had their nostrils plugged with dust. These chicks never moved more than 50 m from the county road and the disturbance caused by passing vehicles could have interferred with normal parental care (especially shading) and/or interferred with normal feeding behavior.

Minor access roads may be useful to curlews if the traffic flow is light. Curlews do use the dust on such roads for bathing. Rain often formed small intermittent pools in these roads. Water in these road catchments remained longer than elsewhere on the upland, and were used by curlews for drinking and bathing.

Chicks are vulnerable to being crushed by vehicle traffic along the trails and roads. This potential problem was more evident in 1978 when the vegetation was very tall and dense on the BCPU. We found one chick (No. 139) that had been run over by a vehicle and Bud Sherrets (pers. comm.) found two.

Although minor access roads allow humans vehicular access to portions of the BCPU range they also tend to limit travel on the range to specific routes. Localization of vehicle travel is beneficial to curlews because (1) it minimizes the amount of travel time across a portion of rangeland and (2) minimizes the amount of area modified by vehicular traffic.

Roads on the BCPU are not generally the shortest route between two points, but are the most expedient route considering the terrain. Without the presence of roads vehicle travel on the BCPU rangeland would be greatly impeded, and therefore would take considerably longer. The longer one spends traveling on the BCPU the greater the probability of interacting with breeding curlews. Curlews respond to the presence of vehicle and humans during the breeding season with anti-predatory behaviors. The stress created by human or vehicle presence causes abandonment of an area if too frequent or prolonged.

Roads allow for localization of modifications induced by vehicle traffic on the BCPU rangeland thereby sparing the remaining habitat. Vehicle traffic not restricted to roads increases the loss of curlew habitat and decreases curlew breeding success (see section on ORV's). Vehicle traffic on roads has virtually no effect on extant vegetation structure, the probability of influencing curlew breeding success by occasional vehicle passage over trails appears trivial. Successful nests have been observed within meters of occasionally used minor access routes.

To the extent that the road system on the BCPU encourages increased travel, it is detrimental to breeding curlews. The passage of vehicles is not particularly bad, but the behavior of the humans who use these roads can be harmful (see section on Associated Human Disturbance). On balance, roads and limited proper use are not bad, but unlimited use is.

Conversion of Rangeland to Human Residences

The conversion of the BCPU rangeland to urban and sub-urban areas poses a direct threat to the survival of curlews on the BCPU. The expanding human population in urban centers of the Treasure Valley has created a need for housing. This need is reflected in the establishment of single family dwellings in formerly rural areas. Several areas were converted from rangeland to rural residences during the course of this study.

The present curlew distribution on the BCPU corresponds negatively to the current distribution of established human residences (Fig. III-17). We infer from this negative correspondence that the establishment of a human residence and all the associated activities are not compatible with curlew breeding activities. Curlews are very densely distributed on rangeland on both sides of the belt of human residences along interstate 84. It is significant that curlew densities are highest in areas with the fewest established residences, and the least amount of human presence.

The establishment of human residences directly effects curlew breeding success in two ways. First, houses, associated out-buildings, yards and other uses of real estate affects the characteristics of curlew habitat. Secondly, human activities in the vicinity of their residences affect curlews adversely as described in the section on Associated Human Disturbances. The establishment of residences on the BCPU breaks up the more or less continuous expanses of rangeland creating instead a mosaic of vegetation types. This reduces the size of available areas of suitable habitat and increases the proportion of area located in edge situations. In the extreme western portion of the BCPU human settlement has resulted in the formation of a mosaic of developed rangeland areas. The rangeland portion of the mosaic snakes out into the developed area such that, although contiguous, it is rarely more than a 1/4 mile wide. The high degree of juxtaposition of rangeland and converted range yield small rangeland areas which are vulnerable to frequent disturbance by human activity. Generally, rangeland which supported high numbers of curlews was more than 1 mile wide and had a low degree of juxtaposition with areas containing human settlement.

Agriculture

Agricultural cultivation is the major use of land surrounding the

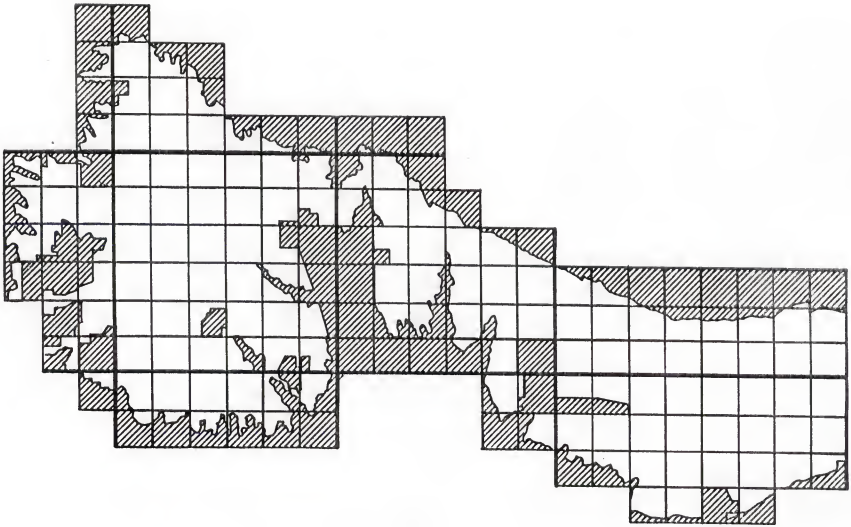


Fig. III-17: Human residences and agricultural conversions on the BCPU are limited to the shaded areas.

rangeland portion of the BCPU and divides the expanse of grassland into local mosaics of differing habitat types. The majority of the cultivation near the BCPU rangeland occurs along highways and Bureau of Reclamation canals. The principal crops are alfalfa seed and hay, seeded pasture, winter and spring wheat, field corn, potatoes and onions. Apple, prune, pear and cherry orchards are grown along the north boundary of the rangeland where air movement is good and frost hazard is low. Beef cattle, dairying, and sheep are important enterprises; the 1969 Census of Agriculture reported livestock numbers in the vicinity of the BCPU as: cattle and calves 50,699; milk cows, 4,395; sheep and lambs, 6,264. Livestock numbers are on the increase because of feedlot enterprises, not because of increased numbers on the range.

Curlews make frequent use of cultivated fields near the breeding areas throughout the breeding phenology. Cultivated alfalfa fields are routinely used for feeding by long-billed curlews nesting on the rangeland portion of the BCPU. We found no curlew nests in intensively cultivated fields nor did we observe territorial defense of such lands. We received a few reports of curlews nesting in alfalfa adjacent to rangeland. Careful and immediate investigation of these reports failed to confirm curlews nesting in agricultural fields. In two cases of reported curlew nesting in alfalfa, the areas resembled more closely stock driveways on the BCPU rangeland than a monoculture of alfalfa. We cannot prove that curlews don't sometimes nest in agricultural fields but is must be rare and must usually fail.

Curlews do use alfalfa and other types of intensively cultivated areas for numerous other activities throughout the breeding cycle. During the arrival periods of all three breeding seasons, we observed curlews in plowed agricultural fields, alfalfa fields, and wet pastures.

In 1979 they made extensive use of such feeding sites. We occasionally observed adult curlews foraging in fallow fields or freshly mowed alfalfa during the pre-laying, laying and incubation periods. Curlew broods sometimes moved out of the BCPU rangelands into alfalfa fields.

The most frequent and intense use of agricultural land by curlews occured during the pre-migratory period. Curlews exhibited pre-migratory activities in a variety of habitat types including the stock driveways of the Little Freezeout area, fallow fields adjacent to the BCPU rangeland, irrigated onion fields and irrigated and/or freshly mowed alfalfa fields.

During the pre-migratory period 1977, we observed flocks of 100 to 200 birds on the stock driveways of the Little Freezeout area. Flocks were observed from sunrise to about 11:00 a.m. MDT, when groups of 7 to 12 individuals would leave the flock and fly to surrounding agricultural fields which were usually being irrigated. In the brood-rearing period of 1977, an unprecedented grasshopper hatch occurred on the BCPU rangeland. Curlews exploited the available food resource by adjusting their spatial behavior to correspond with the location of the resource. In the subsequent years, when the grasshopper hatch was not of the 1977 magnitude, curlews did not use this portion of the rangeland during the pre-migratory period, rather curlews used agricultural areas or other locations highly disturbed by man.

In 1978, several groups of 15 to 35 birds were observed foraging in the South Dewey area in the early mornings of the pre-migratory period. Around

9:00 a.m. MDT the foraging groups coalesced to form flocks of 100 to 200 birds. The flocks moved to a fallow field adjacent to the South Dewey portion of the rangeland where they would remain until sunset. The area used by curlews during the day was adjacent to a seed corn field and drained the excess water from irrigation used on the corn. The vegetation on this area had been removed by bulldozers resulting in a large bare knob (0.5 $\pm$ ha) and pond (0.3 $\pm$ ha). During the period the birds used this area, they loafed and performed maintenance behaviors. An irrigated onion field located south of the Sand Hollow area was used similary by curlews later in the pre-migratory period 1978.

During 1979 we observed the same flocking behavior in a freshly mowed alfalfa field three miles south of the Mud Lake Cow Camp. During the pre-migratory period, curlews adjust their movements to areas which contain food and water. Agriculture land surrounding the BCPU rangeland can be of great benefit to curlews at this time. The curlews did, however, return to the uplands to roost even when they spent most of the day on agricultural land.

Conversion of rangeland to agricultural cultivation poses a direct threat to the curlews on the BCPU by destroying their nesting substrate. Breaking the uniform BCPU rangeland by blocks of cultivation reduces the size of the areas available for nesting and increases the proportion of area located in edge situations. Cultivated vegetation types least resembling 'native' grasslands are planted in vast unbroken fields, while agricultural types most resembling natural habitats, such as fallow fields and pastures, occur in small patches interspersed among other agricultural types. The impact of agricultural cultivation on BCPU vegetation and on curlew behavior was apparent in the Little Freezeout area in 1979.

About 32.4 ha (80 acres) of former rangeland on the east boundary of the Little Freezeout area was converted to agriculture during the early spring 1979. We frequently observed curlews in this area in previous years, however, curlews quit using the area when it was converted. Such major modifications of rangeland simply eliminate the area from curlew use during the critical nesting period.

Curlews are territorial and those birds who formerly held territories and nested on land subsequently converted to agriculture cannot simply crowd into already occupied areas. Effective management of territorial animal, such as the curlew, involves consideration of individual territory size and the total land required to provide enough territories so a population can maintain itself indefinitely in an area. Curlews apparently breed on the BCPU because there is sufficient area for the establishment of territories of a quality which increases the probability of successful breeding attempts. During the early and critical periods of the breeding phenology, curlew territories averaged 0.4 square kilometers (see section on habitat use). Variation in size may reflect variability in the characteristics of the territories, and in the birds' ability to maintain a territory. Territoriality is an important factor that limits population density in many avian species. An increase in intensive agricultural practices on the BCPU would directly decrease the area available for long-billed curlews and could result in the extinction of BCPU curlews. They require large expanses of suitable habitat, isolated, small habitat patches are of limited value. Because the average breeding success during this study was only 0.66 fledged chicks per pair of breeding

curlews, any reduction in the area suitable for territorial defense would threaten the entire BCPU population.

Almost all cultivated fields in the vicinity of the BCPU rangeland are routinely treated with pesticides and herbicides. Avian populations exhibit some sensitivity to pesticides under a variety of conditions. The effects of chlorinated hydrocarbons have received closest study, but currently malathion and toxaphene are being used on western rangelands and adjacent cultivated areas to control grasshoppers and other insect populations (McEwen et al. 1972). Control of these insects can never be of benefit to the curlews, but can be harmful by indirectly killing their food supply or possibly killing the birds directly.

Herbicidal treatments have the potential to affect rangeland bird populations in the same ways. We have no empirical evidence suggesting that pesticides and herbicides affect the curlews on the BCPU, but the potential for such affects always exits. Most chemical treatments are applied by aircraft; wind born chemicals could easily find their way to concentrations of breeding curlews. A common sense approach to management must prevail against the pressures of human population expansion, especially when toxic chemicals are involved.

Associated Human Disturbance

All disturbances influencing the plant and avian communities of the BCPU have an associated human component. Once access to the BCPU rangeland is gained by humans, many of their ensuing activities are insidious in nature and detrimental to the biotic structure of the BCPU. Almost all of the BCPU rangeland not used by curlews has in some way been rendered unsuitable by human activity.

The most insidious human activity is the deposition of refuse on the BCPU range. Littering directly effects curlew breeding attempts by (1) eliminating space which is otherwise suitable for curlew use, (2) creating hazards which may physically damage curlews, (3) providing refugia for predators and (4) inviting people to deposit more refuse, and (5) attracting target shooters and salvagers to the curlew breeding area.

We estimate that approximately 750 ha (1,850 acres) of otherwise suitable curlew habitat has been eliminated due to littering. The majority of this land is located in North Dewey and Little Freezeout which both support very dense concentrations of breeding curlews. The rate at which refuse is deposited on the BCPU rangeland appears to have increased during the period of this study. The BCPU is located on the nexus of the boundaries of four counties: Canyon, Payette, Gem and Ada. Although an established landfill is located on the BCPU its use is restricted to residents of Gem County. Residents of the other three counties must travel several miles to properly dispose of refuse and often opt to deposit refuse on the rangeland. Attempts at restricting access to the range have been ineffective in solving or even slowing this activity.

The nature of the refuse deposited on BCPU range influences curlew breeding activity. The refuse deposited on the BCPU range runs the gamut from car bodies and large appliances to grass clippings and waste paper.

Frequently, dead livestock and pets were deposited on the range. Large aggregations of derelict refrigerators, furnances and furniture create obvious interruptions in the field of view of breeding curlews. Curlews apparently require a continuously uninterrupted field of view in order to carry out their communications which serve to maintain their breeding space and to detect potential predators.

Broken glass and other sharp objects potentially threaten the physical well-being of curlews. Throughout the study, we occasionally observed curlews with varying degrees of damage in their feet and legs, especially in the Little Freezeout area. We have no empirical evidence which indicates refuse is responsible for the condition of these crippled individuals, however, more crippled individuals have been observed in areas characterized by large quantities of refuse than in areas of similar curlew concentration characterized by little refuse. We believe the potential of sharp refuse damaging curlew feet to be great. We frequently encountered large tangles of wire from electric fencing, abandoned on the BCPU range. On more than one occasion wire has entangled a researcher or his vehicle thereby causing an accident. Wire is virtually invisible when abandoned in the grass and for that reason may also pose a potential threat to the physical well being of breeding curlews.

Aggregations of refuse provide attractive habitat for curlew predators. The aggregation's heterogeneity of structure and rotting organic material no doubt attract rodents and mustellids as well as canids from surrounding agricultural areas. Clearly the presence of these predators has detrimental effects on the breeding success of curlews on the BCPU (see chick and egg mortality). The worst aspect of littering was that it invited more littering nearby, not, unfortunately, on the same exact site, just nearby.

The presence of refuse on BCPU range attracts target shooters and salvagers. The potential impact of target shooters is obvious. Breeding curlews, especially those with chicks, because of their behavior provide attractive targets. Every year we have encountered people either attempting to shoot curlews or talking about shooting curlews. In 1977, shooters apparently killed six curlews and in 1980 when only one biologist was on the BCPU another six curlews were found dead, freshly shot. The shooting of curlews is a serious threat to this population.

Human activity such as salvaging, hiking, camping, and partying all have impact on curlew breeding activity. Curlews can tolerate occasional disturbance by humans, however, if the disturbance is too frequent or prolonged it may cause abandonment of territories and nests, or the displacement of the family unit to a less suitable area, thereby decreasing the probability of successful breeding. Curlews responded to human presence with anti-predatory behaviors at all times during the breeding phenology except during the pre-migratory period. The response was most intense when the adults have chicks and increased as the amount of harrassment increased. An unknowledgeable person or group may unintentionally harrass a curlew to the point of abandonment. Curlews are attractive and extraordinary birds to observe, and therefore prolonged interaction often occurs. The potential for such interactions with breeding curlews is enhanced by the easy access to the rangeland from the surrounding agricultural and residential areas. Restricting access to the range may be necessary in order to decrease the frequency with which people interact with breeding curlews.

CHAPTER IV

LONG-BILLED CURLEW DISTRIBUTION, ABUNDANCE, AND HABITAT USE

CURLEW DISTRIBUTION

Relatively large numbers of Long-billed Curlews nested on the BCPU each spring. For the duration of this study, however, curlew distribution across the entire BCPU was not uniform at any time of the season. Patterns of curlew use and non-use varied greatly in response to a complex array of environmental and social factors which also varied greatly among years.

Methods

Because of the large area involved, we measured curlew breeding densities and distribution on two different scales simultaneously. At regular intervals for the duration of the study, we surveyed the entire BCPU to obtain relative indices of curlew abundance. In addition, we obtained absolute measures of abundance on smaller study plots each year.

By late April 1977, we had established a 72.8 km route along pre-existing dirt roads or trails through all major portions of the BCPU upland except the Homestead and Dewey areas (Fig. IV-1 and Table IV-1). This survey route was driven weekly through 26 June by one person. For each survey, the date, location, and sex of all curlews sighted were recorded onto maps (USGS 7.5 minute series, topographic, scale = 1:24000). Surveys were driven in full daylight between 0700 and 1900 hours, and they were suspended or postponed during periods of heavy rain and/or high wind.

The standardized survey route was expanded to about 204 km in 1978 and 1979 (Fig. IV-1). It consisted of eleven component routes (Table IV-1) which were driven in one day twice weekly from 6 April - 9 July, 1978. Starting times and order in which we drove each component route were rotated each survey using a modified Sheffe matrix to insure sampling different areas at different times of day. Survey procedures were similar in 1979 except that the route changed slightly and was driven only once each week from 26 March - 13 July, 1979.

Each component route sampled a different census block of the BCPU (Fig. IV-2). These blocks conformed to specific sub-sections or grazing treatment areas of the BCPU.

From April through June, 1977, we evaluated spot-mapping, nest location, and several transect methods for censusing curlews breeding on a 350 ha study plot in the Sand Hollow block. In 1978 and 1979 we selected a different and larger study plot, about 1600 ha within the Little Freezeout block where we concentrated on spot-mapping and strip transect methods for estimating curlew breeding densities (see Redmond et al. 1981 for detailed methods and results).

Results and Discussion

Each year in every census block, we observed greater mean numbers of males per km per survey than females (Tables IV-2 and IV-3). These differences were

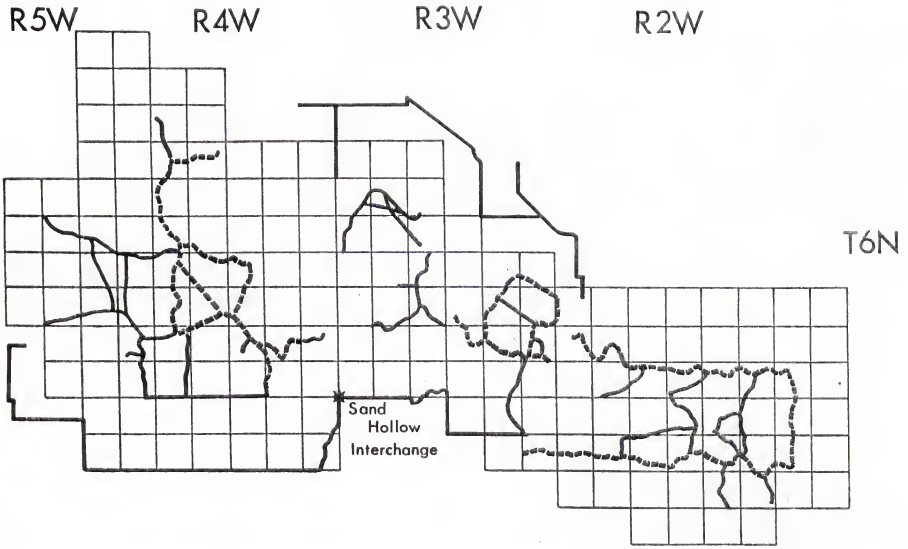


Fig. IV-1: Map of the standardized survey route on the BCPU. Dashed lines refer to 1977 portion of the route. See Fig. IV-2 for boundaries of the 11 census blocks.

Table IV-1. Length of survey routes according to census block and year on the BCPU.

Census Block		Length of Route in km		
Abbrev.	Name	1977	1978	1979
HIGH	High	5.10	10.23	10.23
HMST	Homestead	0	7.65	7.65
SHAW	Shaw	8.40	9.53	9.53
SNDH	Sand Hollow	14.50	29.13	32.23
DEWY	Dewey	0	17.98	19.21
LFZO	Little Freezeout	14.62	21.32	21.32
HTLY	Hartley	10.52	15.06	17.58
MDLK	Mud Lake	10.82	19.47	17.98
WTBD	Whitebird	8.83	12.60	7.35
NOAG	N. Agriculture	0	26.60	26.60
SOAG	S. Agriculture	0	34.50	34.50
TOTALS		72.79	204.07	204.18

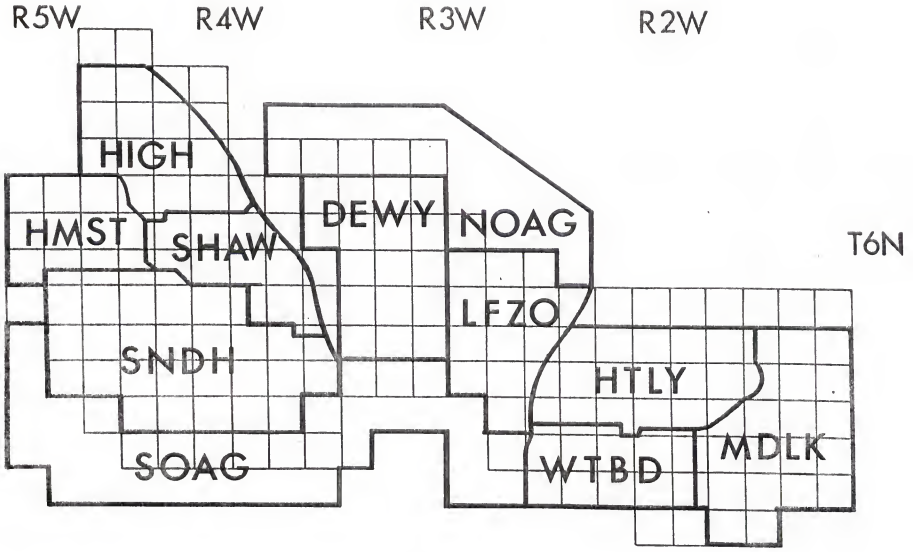


Fig. IV-2: Map of the 11 census blocks on the BCPU.

greatest during pre-laying through incubation and in many cases were statistically significant in spite of large variances.

One cannot infer from these data, however, that there were many more males on the BCPU than females. Although mean number of males seen per km in Little Freezeout was more than double the female mean in 1978 and almost double in 1979, spot map results indicate that 79% and 85% of the territorial males may have been mated in 1978 and 1979 (Figures IV-3 and IV-4). There are several possible reasons why these percentages may be underestimates (see Redmond et al. 1981).

We conclude that male curlews were more detectable than females, particularly during the pre-laying through incubation periods. At this time many males actively performed aerial display flights or otherwise tended to occupy more conspicuous locations (see Undulating Flight Display section, Chap. II). In contrast, females did not perform flight displays; during pre-laying and laying they spent more time feeding than males; and after laying, females spent more daylight hours incubating than did males. Thus, for at least these three reasons, we would expect females to be less detectable than males, particularly in a year such as 1979 when food was difficult to obtain on nesting territories, and females spent much time feeding off their territories.

There was a tendancy for the mean numbers of both sexes seen on the survey counts to increase between the earlier phases and the brood rearing phase each year (Tables IV-2 and IV-3). These increases were consistent with important behavioral changes which followed hatching and affected detectability of both sexes. During brood rearing males sometimes flew more than 500 m to engage in cooperative mobbing of potential chick predators (including us). At this time females tended chicks and also joined in the mobbing of potential predators although they did not fly as far as males to join mobbing groups.

For these reasons counts of male curlews taken during brood rearing may reflect excessive numbers, while counts of female curlews taken during the earlier phases of the breeding cycle substantially underestimate their numbers. Results of spot-mapping and transect sampling in Little Freezeout during 1978 and 1979 support this interpretation (see Redmond et al. 1981). These results also indicate that accurate estimates of curlew breeding density can be obtained from counts of just males taken during the pre-laying through incubation period. Female counts taken during brood rearing do not reflect total numbers attempting to breed, because curlews that lose their clutch (or brood) disappear within a few days and probably leave the BCPU. These female counts still may provide a useful index of brood density, and perhaps even of annual reproductive success if used in conjunction with male density estimates for the pre-laying through incubation period (see Redmond et al. 1981).

For further analysis and for the estimation of annual curlew breeding densities within each census block, we used tallies of male curlews from pre-laying through incubation and added counts of solitary females. In so doing we made two assumptions: 1) that each sighting of an unattended female implied the non-detection of a male from that immediate area, and 2) that we were not counting these undetected males elsewhere. Further reference to mean numbers of males denotes the inclusion of solitary females as well.

Table IV-2. Mean numbers of male Long-billed Curlews seen per km per census survey of the BCPU during pre-laying through incubation (PL-INC) and during brood rearing in 1977-1979.

Census Block	$\bar{x}$ no. of male curlews seen/km/survey ± SD:											
	1977				1978				1979			
	PL-INC	(n)	Brood-rearing	(n)	PL-INC	(n)	Brood-rearing	(n)	PL-INC	(n)	Brood-rearing	(n)
HMST	0.750 ± 0.486	(5)	1.03 ± 0.208	(5)	1.08 ± 0.346	(8)	1.30 ± 0.282	(9)	1.20 ± 0.422	(5)	1.67 ± 0.653	(5)
HIGH	0.658 ± 0.088	(4)	1.96 ± 0.758	(5)	1.22 ± 0.593	(8)	1.23 ± 0.293	(10)	1.39 ± 0.307	(5)	1.20 ± 0.484	(6)
SNDH	0.817 ± 0.290	(5)	1.48 ± 0.734	(5)	1.59 ± 0.408	(8)	1.60 ± 0.513	(9)	1.37 ± 0.416	(6)	1.55 ± 0.925	(5)
NDEW	-------		-------		1.11 ± 0.343	(8)	1.37 ± 0.230	(8)	0.521 ± 0.199	(6)	0.704 ± 0.404	(5)
SDEW	-------		-------		1.24 ± 0.425	(7)	1.64 ± 0.351	(8)	1.52 ± 1.11	(6)	2.92 ± 1.51	(6)
LFZO	1.01 ± 0.617	(5)	1.44 ± 0.488	(5)	1.28 ± 0.622	(9)	2.39 ± 0.899	(9)	1.22 ± 0.311	(10)	1.11 ± 1.05	(12)
WTBD	-------		1.39 ± 0.386	(5)	0.724 ± 0.181	(7)	1.01 ± 0.321	(10)	0.753 ± 0.289	(6)	0.853 ± 0.151	(5)
MDLK	-------		0.678 ± 0.325	(5)	0.635 ± 0.223	(8)	0.500 ± 0.207	(9)	0.612 ± 0.148	(5)	0.818 ± 0.409	(5)
NOAG	-------		-------		0		0		0		0	
SOAG	-------		-------		0		0		0		0	

Table IV-3. Mean numbers of female Long-billed Curlews seen per km per census survey of the BCPU during pre-laying through incubation (PL-INC) and during brood-rearing in 1977-1979.

Census Block	$\bar{x}$ no. of male curlews seen/km/survey + SD:							
	1977				1978		1979	
	PL-INC	(n)	Brood-rearing	(n)	PL-INC (n)	Brood-rearing (n)	PL-INC (n)	Brood-rearing (n)
HMST	0.279 ± 0.168	(5)	0.618 ± 0.377	(5)	0.470 ± 0.217 (8)	0.678 ± 0.294 (9)	0.669 ± 0.320 (5)	0.892 ± 0.610 (5)
HIGH	0.482 ± 0.263	(4)	1.54 ± 1.07	(5)	0.584 ± 0.389 (8)	0.720 ± 0.268 (10)	0.720 ± 0.223 (5)	0.511 ± 0.297 (6)
SNDH	0.473 ± 0.180	(5)	1.27 ± 0.545	(5)	0.660 ± 0.266 (8)	0.877 ± 0.399 (9)	0.628 ± 0.210 (6)	1.05 ± 0.586 (5)
NDEW	-------		-------		0.440 ± 0.244 (8)	0.715 ± 0.327 (8)	0.251 ± 0.116 (6)	0.391 ± 0.198 (5)
SDEW	-------		-------		0.692 ± 0.345 (7)	1.01 ± 0.385 (8)	0.361 ± 0.290 (6)	1.53 ± 0.679 (6)
LFZO	0.768 ± 0.305	(5)	0.993 ± 0.964	(5)	0.562 ± 0.449 (9)	1.35 ± 1.24 (9)	0.645 ± 0.336 (10)	0.774 ± 0.608 (12)
WTBD	-------		0.896 ± 0.262	(5)	0.724 ± 0.181 (7)	0.492 ± 0.195 (10)	0.179 ± 0.091 (6)	0.222 ± 0.096 (5)
MDLK	-------		0.393 ± 0.081	(5)	0.269 ± 0.092 (8)	0.265 ± 0.143 (9)	0.329 ± 0.048 (5)	0.388 ± 0.297 (5)
NOAG	-------		-------		0	0	0	0
SOAG	-------		-------		0	0	0	0

Fig. IV-3. Spot-mapping territories in Little Freezeout census block during pre-laying through incubation, 1978. ? indicates that no female was ever observed on a territory. N = 104 territories, 22?, 20 sampling days, 33 nest sites, and 570 contacts.

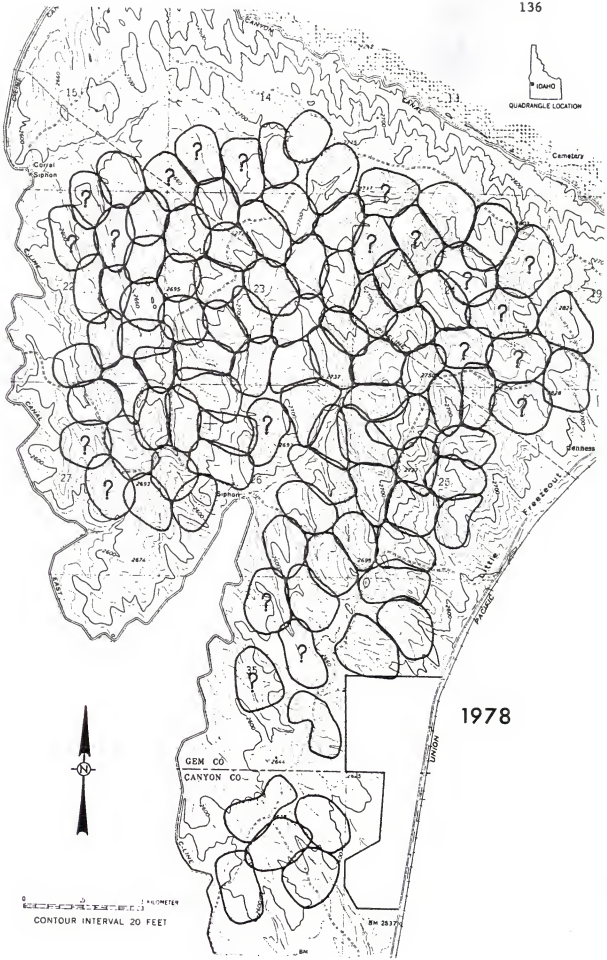
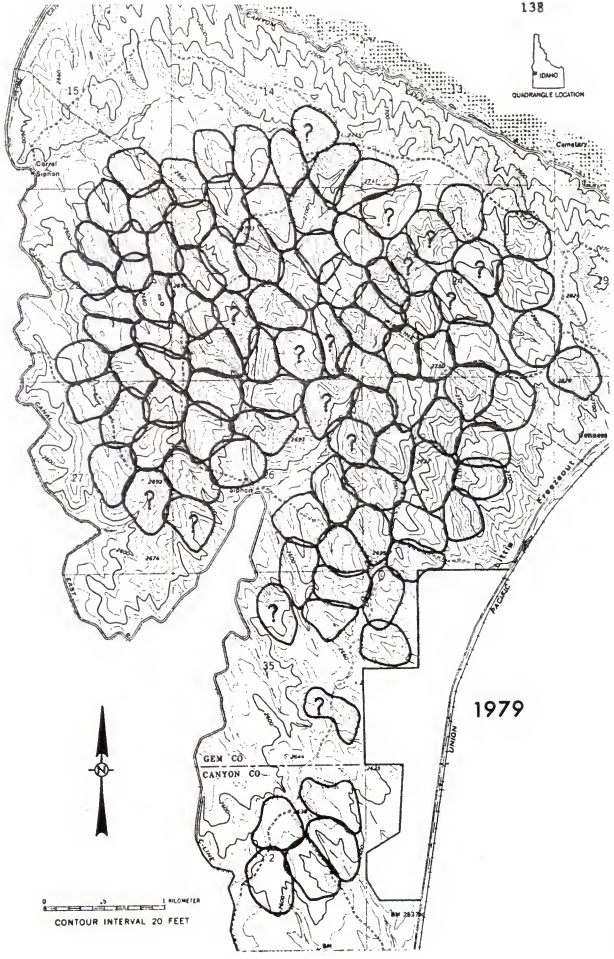

IDAHO
QUADRANGLE LOCATION
1978
GEM CO
CANYON CO
N
CONTOUR INTERVAL 20 FEET
KILOMETER
Canyon
Union
Ferguson
Ridge
Cemetary
Tenness
Corral
Siphon
BM 2937

Fig. IV-4. Spot-mapping territories in Little Freezeout census block during pre-laying through incubation, 1979. ? indicates that no female was ever observed on a territory. N = 101 territories, 15 ??, 25 sampling days, 25 nest sites, and 839 contacts.


IDAHO
QUADRANGLE LOCATION
1979
GEM CO
CANYON CO
CONTOUR INTERVAL 20 FEET
KILOMETER

Mean numbers of males seen during pre-laying through incubation ranged from 1.02 km in 1979 to 1.08 per km in 1978 for the entire BCPU survey route (Table IV-4). Differences among the three annual means were not significant ($F = 0.160$, $df = 2/127$). However, differences between mean numbers of males seen per km among the nine census blocks within each year (Table IV-5) were highly significant (1977: $F = 5.72$, $df = 6/19$, $p < .01$; 1978: $F = 27.4$, $df = 8/50$, $p < .0001$; and 1979: $F = 55.2$, $df = 8/36$, $p < .00001$).

Each year we sighted significantly fewer males per km in the HTLY, SHAW, and HMST census blocks than in the other blocks ($p < .05$, Table IV-6). Mean numbers of males seen annually in HIGH, MDLK, and WTBD generally were intermediate and never differed significantly from one another ($p > .05$, Table IV-6). In 1978 and 1979, mean counts of males per km were greatest in SNDH, LFZO, and DEWY, and not significantly different from one another ($p > .05$, Table IV-6).

We conclude that breeding Long-billed Curlews were unevenly distributed over the BCPU. The birds preferred short vegetative cover, and there were large areas unsuitable for them on the BCPU (e.g. crested wheatgrass plantings, sagebrush stands, agricultural developments, etc.).

The proportion of suitable rangeland varied greatly among census blocks (Table IV-7). Because our survey route did not pass through each vegetative cover type in proportion to its occurrence within every census block, we recalculated our index to obtain numbers of male curlews seen per km of suitable upland during pre-laying through incubation in each census block.

There were no significant differences between mean numbers of males seen per suitable km per survey among the three years ($F = 0.111$, $df = 2/127$; Table IV-8). Differences among census blocks were highly significant in 1978 and 1979 (1978: $F = 11.1$, $df = 8/50$; $p < .00001$; 1979: $F = 22.0$, $df = 8/36$, $p < .00001$; Table IV-9). In 1977, however, the differences were not significant ($F = 2.48$, $df = 6/19$, $p = .06$) probably because of small sample sizes (2 surveys each) and large variances from the HTLY, MDLK and WTBD census blocks (Table IV-9).

Significantly fewer males were seen per suitable km in the HTLY and SHAW census blocks than all other blocks in 1978 ($p = .05$). In 1979 significantly fewer males were seen per suitable km in HTLY, SHAW, and HMST than in the six other blocks ($P = .05$, Table IV-10). The highest mean values were recorded in WTBD in 1977 and 1979, and in DEWY in 1978.

SNDH was the only census block in which mean numbers of males seen both per km and per suitable km per survey differed significantly among years (x per km: $F = 16.4$, $df = 2/12$, $p < .001$; x per suitable km: $F = 20.8$, $df = 2/12$, $p = .0001$). The relative counts of males in SNDH were significantly lower in 1977 than in 1978 or 1979 when we substantially increased the number of km surveyed (Table IV-1). SNDH was the largest census block, and curlews were not distributed uniformly within it. The greater survey efforts in 1978 and 1979 resulted in our sampling more areas in which curlews were concentrated than in 1977. Thus mean counts of males per km (and per suitable km) per survey were significantly lower in 1977 probably because of sampling

Table IV-4. Numbers of male Long-billed Curlews seen per km per survey during pre-laying through incubation long the entire BCPU survey route and among years 1977-79.

Year	N[a]	Mean ± 95% CI	Range Min.	Range Max.
1977	26	1.04 ± .200	.238	2.04
1978	59	1.08 ± .143	.105	2.06
1979	45	1.02 ± .158	.105	1.77
Total	130	1.05 ± .092	.105	2.06

[a]N = number of surveys X number of census blocks.

Table IV-5. Mean numbers of male Long-billed Curlews seen per km per survey during pre-laying through incubation on the BCPU, 1977-79.

Census Block	$\bar{x}$ ♂♂/km/survey ± 95% CI		
	1977	1978	1979
HIGH	1.10 ± .584	1.25 ± .342	1.22 ± .185
HMST	---------	.549 ± .290	.340 ± .246
SHAW	.476 ± .276	.341 ± .197	.315 ± .184
SNDH	1.06 ± .232	1.50 ± .136	1.51 ± .116
DEWY	---------	1.63 ± .321	1.46 ± .239
LFZO	1.49 ± .214	1.52 ± .205	1.43 ± .049
HTLY	.475 ± 1.21	.343 ± .135	.285 ± .128
MDLK	1.11 ± 5.86	1.16 ± .113	1.27 ± .137
WTBD	1.59 ± 5.78	1.32 ± .186	1.40 ± .446

Table IV-6. Mean number of male Long-billed Curlews seen per km per survey in each census block. A continuous line under adjacent blocks indicates that the values do not differ significantly ($p = .05$) from one another, but do differ significantly from those not underlined.[a]

Year					1977				
Census block:	HTLY	SHAW	SNDH	HIGH	MDLK	LFZO	WTBD		
Mean	.475	.476	1.06	1.10	1.11	1.51	1.59		
Year					1978				
Census block:	SHAW	HTLY	HMST	MDLK	HIGH	WTBD	SNDH	LFZO	DEWY
Mean	.341	.343	.549	1.16	1.25	1.32	1.50	1.52	1.63
Year					1979				
Census block:	HTLY	SHAW	HMST	HIGH	MDLK	WTBD	LFZO	DEWY	SNDH
Mean	.307	.315	.340	1.22	1.27	1.40	1.43	1.46	1.51

[a] Results of Duncan's Multiple Range Test at .05 level of significance.

Table IV-7. Amount of non-suitable range in each of the nine census blocks on the BCPU.

Census Block	Total Hectares	Non-suitable area (ha): CWG[a]	Sage[b]	Other[c]	Total	%
HIGH	2386	347	75	42	464	19.4
HMST	1530	408	32	268	708	46.3
SHAW	2120	912	---	325	1237	58.3
SNDH	5362	540	147	366	1053	19.6
DEWY	1448	52	13	---	65	4.5
LFZO	2056	---	123	32	155	7.5
HTLY	2774	438	56	78	572	20.6
MDLK	2358	---	---	308	308	13.1
WTBD	1573	---	203	---	203	12.9
TOTALS	21607	2697	649	1419	4765	22.1

[a]CWG = area of crested wheatgrass.

[b]Sage = area of sagebrush or other shrubby vegetative cover.

[c]Other = area of other non-suitable vegetative cover, includes agricultural lands, ORV use areas, dumps, etc.

Table IV-8. Numbers of male Long-billed Curlews seen per suitable km per survey during pre-laying through incubation along the entire BCPU survey route and among years 1977-79.

Year	N[a]	Mean ± 95% C.I.	Range Min.	Range Max.
1977	26	1.21 ± .203	.474	2.48
1978	59	1.25 ± .133	.202	2.08
1979	45	1.21 ± .159	.202	2.47
TOTAL	130	1.23 ± .089	.202	2.48

[a]N = number of surveys X number of census blocks.

Table IV-9. Mean numbers of male Long-billed Curlews seen per suitable km per survey during pre-laying through incubation on the BCPU, 1977-79.

Census Block	$\bar{x}$ ♂♂/km/survey ± 95% CI		
	1977	1978	1979
HIGH	1.10 ± .584	1.25 ± .343	1.22 ± .184
HMST	---------	1.24 ± .655	.767 ± .555
SHAW	.948 ± .550	.657 ± .380	.606 ± .355
SNDH	1.06 ± .232	1.57 ± .143	1.58 ± .121
DEWY	---------	1.64 ± .322	1.47 ± .244
LFZO	1.54 ± .203	1.63 ± .309	1.53 ± .054
HTLY	.708 ± 1.80	.477 ± .188	.404 ± .141
MDLK	1.52 ± 8.91	1.38 ± .137	1.53 ± .162
WTBD	1.93 ± 7.00	1.50 ± .210	1.95 ± .623

Table IV-10. Mean number of male Long-billed Curlews seen per km of suitable habitat per survey in each census block. See legend for Table IV-6.

Year					1977				
Census block:	HTLY	SHAW	SNDH	HIGH	MDLK	LFZO	WTBD		
Mean	.708	.948	1.06	1.10	1.52	1.54	1.93		
Year					1978				
Census block:	HTLY	SHAW	HMST	HIGH	MDLK	WTBD	SNDH	LFZO	DEWY
Mean	.447	.657	1.24	1.25	1.37	1.50	1.57	1.63	1.64
Year					1979				
Census block:	HTLY	SHAW	HMST	HIGH	DEWY	MDLK	LFZO	SNDH	WTBD
Mean	.404	.606	.767	1.22	1.47	1.53	1.53	1.58	1.95

effort, and not becuse there were actually fewer numbers of curlews breeding in the census block.

CURLEW ABUNDANCE

Methods

To convert mean numbers of male curlews seen per suitable km (Table IV-9) into estimates of breeding density, we calculated annual constants (based on data from the Little Freezeout census block). By dividing annual density estimates for males in Little Freezeout (obtained from a variable distance strip transect analyses described in Redmond et al. 1981) by the corresponding mean numbers of males seen per suitable km per survey in this census block (Footnotes in Table IV-11). Multiplying these constants by means per suitable km gave density estimates (per 100 suitable ha) for each census block. Multiplying suitable area in each census block (total area minus CWG, Sage, and Other in Table IV-7) by density yielded estimates of absolute numbers of male curlews attempting to breed in each census block. Numbers of actual breeding pairs were probably between 85% and 100% of the male values of each year.

Results

Survey counts and resulting estimates were more viable in 1977 than in 1978 or 1979 (Tables IV-5, IV-9, IV-11 and IV-12). Observation conditions were good in 1977, and high variances were associated only with the HTLY, MDLK, and WTBD census blocks because we were late in establishing survey routes through these areas and our sample size for the pre-laying through incubation period was only two surveys.

For the two years with complete data, male density estimates ranged from 1.74 males/100 ha (suitable) in HTLY, 1979, to 8.40 males/100 ha (suitable) in WTBD, also in 1979 (Table IV-11). The SNDH census block was largest and supported the most curlews in all years, whereas the SHAW census block supported the fewest (Table IV-12). An estimated 953 $\pm$ 180 male curlews attempted to breed on the BCPU in 1978 and 945 $\pm$ 154 tried to do so in 1979 (Table IV-12).

CURLEW USE AREAS

Some portions of the BCPU were more suitable for curlew use at certain times than were others. The habitat charactertistics required by curlews were not evenly distributed over the BCPU. Not only was the BCPU rangeland a complex association of overlapping floral and faunal types but it was strongly and unevenly influenced by human land use practices which further increased the spatial and temporal variability of the habitat.

The literature is replete with research concerning habitat requirements of breeding birds. In general a few primary requirements appear to be most important; 1) land area suffiently large to contain a nesting and/or feeding territory (or territories for several pairs in the case of colonial and semi-colonial birds), 2) an adequate food base, 3) suitable topography, 4) suitable

Table IV-11. Estimated mean number of male Long-billed Curlews attempting to breed per 100 ha of suitable upland on the BCPU, 1977-79.[a]

Census Block	Suitable Area (ha)	$\bar{x}$ ♂♂/100 ha ± 95% CI		
		1977[b]	1978[c]	1979[d]
HIGH	1922	4.31 ± 2.29	5.39 ± 1.48	5.26 ± 0.79
HMST	822	?	5.34 ± 2.82	3.31 ± 2.39
SHAW	883	3.72 ± 2.16	2.83 ± 1.64	2.61 ± 1.53
SNDH	4309	4.16 ± 0.91	6.77 ± 0.62	6.81 ± 0.52
DEWY	1385	?	7.07 ± 1.39	6.34 ± 1.05
LFZO	1901	6.04 ± 0.80	7.03 ± 1.33	6.59 ± 0.23
HTLY	2202	2.78 ± 7.06	2.06 ± 0.81	1.74 ± 0.61
MDLK	2050	5.96 ± 34.9	5.95 ± 0.59	6.59 ± 0.70
WTBD	1370	7.57 ± 27.4	6.47 ± 0.91	8.40 ± 2.69

[a] Estimates based on mean numbers of males seen per suitable km per survey (Table IV-9) and conversion factors given below.

[b] 1977 conversion factor = 6.04/1.54 = 3.92; see text for details.

[c] 1978 conversion factor = 7.02/1.63 = 4.31.

[d] 1979 conversion factor = 6.60/1.53 = 4.31.

Table IV-12. Estimated number of male Long-billed Curlews attempting to breed in each census block on the BCPU, 1977-79.

Census Block	Area (ha)	Estimated no. ± 95% CI: 1977	1978	1979
HIGH	1922	82.8 ± 44.0	104.0 ± 28.4	101.0 ± 15.2
HMST	822	-------	43.9 ± 23.2	27.2 ± 19.6
SHAW	883	32.8 ± 19.1	25.0 ± 14.5	23.0 ± 13.5
SNDH	4309	179.0 ± 39.2	292.0 ± 26.7	293.0 ± 22.4
DEWY	1383	-------	97.8 ± 19.2	87.7 ± 14.5
LFZO	1901	115.0 ± 15.2	134.0 ± 25.3	125.0 ± 4.4
HTLY	2202	61.2 ± 155	45.4 ± 17.8	38.3 ± 13.4
MDLK	2050	122.0 ± 715	122.0 ± 12.1	135.0 ± 14.4
WTBD	1370	104.0 ± 375	88.6 ± 12.5	115.0 ± 36.9
TOTALS	16842		953 ± 180	945 ± 154

vegetation structure, 5) predation/competition below some critical level (Hilden 1965, Verner 1975, Balda 1975). In general, vegetative structure and food are closely linked because the vegetative structure either is the food, or it is the food base for the birds' prey.

Variation in one or a combination of any of these requirements on the BCPU may account for the variation in the distribution of breeding curlews and hence "use areas". Curlews localized much of their behavior on nesting territories which they actively defended from conspecifics during the pre-laying, laying and incubation periods. Frequently, adults also foraged on areas apart from their nesting territory. During the brood-rearing period, defense of the territories ceased and family units moved off to forage on other nearby parts of the rangeland. The nesting territories and areas used by adults for feeding or by adults with broods were all curlew "use areas". Those portions of the BCPU not used by curlews for nesting or foraging were designated "non-use areas".

It was impractical to evaluate the characteristics of each nesting territory and foraging area on the BCPU. Therefore, we employed four grains of evaluation and presentation to describe habitat characteristics of areas which received heavy curlew use and compared these to areas of lesser and non-use. The four grains of evaluations are: (1) levels of intensity of curlew use, (2) curlew use of the 30 vegetation types, (3) curlew use of each section ($mile^2$) of the BCPU rangeland, and (4) habitat use based on the activity budget analysis.

Level of intensity of curlew use was determined by ordering the 30 vegetation types according to the mean number of curlews observed in each (1977-1979) and arbitrarily dividing these into eight levels with varying numbers of curlews (levels of use)(Table IV-13). Vegetative characteristics for each level of use were derived from the means for the importance values recorded in each of its component vegetation types.

This course grain evaluation is of value in determining the general location and vegetative characteristics of clusters of individual curlew use areas (Figure IV-5). The mean number of curlews per level of use area does not result in the same ordination as the density of curlews observed in each area, however these two parameters are significantly correlated ($r_s = 0.84$, $p \leq 0.05$)(Table IV-14). Generally, curlews were observed in only certain portions of each area during any survey. In most cases small portions of a level of use area contained the majority of the curlews observed during a survey. Therefore, density values from this coarse grain evaluation are of minimum value in determining the degree of curlew use of each level. The greater the mean number of curlews observed per level the greater the amount of suitable curlew habitat in that area. The size and topography of suitable curlew habitat was not easily resolved at this grain. However, general trends in vegetation structure within and amongst the levels were resolvable.

We constructed a series of ordinations to describe the effects of plant species importance on curlew habitat suitability. For each period of the breeding seasons, brood-rearing 1977 through brood-rearing 1979, we calculated the mean importance value of each plant species (having an importance value $\geq$ .05) in each of the eight levels of use areas. Each level of use was characterized by a stand of vegetation which varied in plant species composition and

Table IV-13: Curlew numbers in the eight different "levels of use" on the BCPU.

Level of Use	Vegetation Types	Range of Curlews Obs. 1977, 78, 79	Mean No. Curlews Obs.	Sd	Percent of all Curlews Obs.	Rank
A	12	1753	1753.00	0.0	35.70	1
B	1,28	1408-1314	1361.00	66.5	27.70	2
C	15,14	1045-949	997.00	67.9	20.30	3
D	27,22,21,7	697-493	601.25	99.2	12.25	4
E	9,3,24,6	166-104	133.00	25.4	2.71	5
F	23,16,8,2,4,10	80-26	52.80	19.6	1.07	6
G	26,20,19	13-5	9.30	4.0	0.19	7
H	5,17,13,11,18, 25,29,30	-0	0.00	0.0	0.00	8

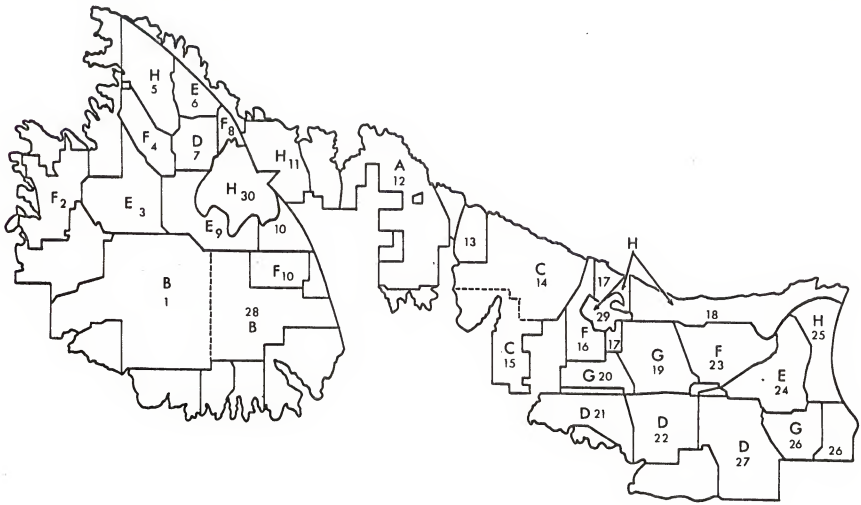


Fig. IV-5: Distribution of the 8 "levels of use" areas among the 30 vegetation types on the BCPU.

Table IV-14: Curlew density on each of the eight "levels of use" of areas.

Level of Use	Number of Hectares	Total Number of Curlews Obs. 1977-79		Density of Curlews	
		No.	Rank	No./Ha	Rank
A	5252	1753	1	0.33	2*
B	17342	2722	2	0.16	3
C	4622	1914	3	0.41	1
D	7120	2405	4	0.33	2*
E	7702	532	5	0.07	4
F	9399	270	6	0.03	5
G	4741	28	7	0.01	6
H	10417	0	8	0.00	7

* Tie

plant species importance. Because level "A" supports the greatest amount of curlew use area, level "A" vegetation stands were compared to the vegetation stands which characterize the rest of the levels of use in order to determine whether they differ from the most suitable condition as defined by curlew numbers.

All levels of use areas are 47 to 88 percent similar in plant species importance from brood-rearing 1977 through brood-rearing 1979 (Table IV-15). No pattern of variation in diversity was apparent between levels of use areas during any period of the breeding season nor between periods of the breeding seasons. However, it was striking that all levels were characterized by similar vegetation structure as we have measured it. Much of the similarity between stands and between periods of the breeding season is due to the ubiquitous nature of dense patches of cheatgrass brome. The great majority of the variation in diversity between levels and periods was due to variation in the frequency and importance of bunch grasses and relatively tall, dense or clumped forbs. Curlews apparently did not respond to plant species' importance, at least as we have measured it. Importance values do not include measurements for height or vertical coverage which are the important variables to which curlews respond.

The mean number of curlews observed per level of use area and the mean height of vegetation were significantly negatively correlated for every period of the breeding season from brood-rearing 1977 through brood-rearing 1979 (except brood-rearing 1978)(Table IV-16 and Figure IV-6). The 1978 breeding season was characterized by a very wet late spring which resulted in extremely tall, dense stands of cheatgrass brome on almost all of the BCPU. The entire study area was characterized by cheatgrass brome which averaged 2.0 ± 0.25 dm tall. This extremely small variance illustrates the uniform response of cheatgrass to the unusual weather. No correlation between curlew numbers and heights of vegetation during this period should be expected.

Curlews also responded negatively to dense vertical coverage. The mean number of curlews and vertical coverage of vegetation at all distances measured (5, 10, 15, 20, 25 meters from the vision board) were significantly negatively correlated during most of the periods from brood-rearing 1977 through brood-rearing 1979 (Table IV-17). In 1978 curlews located their nests preferentially in short vegetation, but the lush growth of 1978 eliminated the differences and the correlations disappeared. When the chicks hatched the birds were able to move to areas of shorter vegetation.

Vertical coverage values reflect the homogeneity of the growth form because they were taken at a variety of distances from the vision board. Uniformly low values of vertical coverage resulted from homogeneously short vegetation, while uniformly highly values resulted from homogeneously tall, dense vegetation. Vertical coverage values increase with distance where short vegetation is interspersed with plants of tall and wide growth forms or where the vegetation varies radically in height and density. Each of these four types of vegetation homogeneity yielded a characteristic array of values from the five distances at which vertical coverage was measured (Table IV-18). Levels of use A, B and C (Appendix Table IV-3) were dominated by homogeneously short vegetation while the levels D-H were characterized by decreasing proportions of short vegetation. Although homogeneously short associations are transitory each growing season, the continuous nature of some disturbances

Table IV-15. Percent similarity of plant species importance parameters for each "level of use". B = brood-rearing period, P = pre-laying period, L = laying period, I = incubation period.

Levels of Use	Percent Similarity[a]								
	1977	1978				1979			
	B	P	L	I	B	P	L	I	B
A	--	--	--	--	--	--	--	--	--
B	0.63	0.62	0.59	0.52	0.47	0.59	0.64	0.62	0.60
C	0.53	0.69	0.63	0.76	0.77	0.67	0.71	0.63	0.68
D	0.62	0.67	0.65	0.69	0.66	0.62	0.71	0.69	0.71
E	0.68	0.73	0.74	0.78	0.68	0.52	0.73	0.67	0.63
F	0.79	0.68	0.76	0.72	0.71	0.56	0.66	0.62	0.75
G	0.88	0.74	0.75	0.61	0.68	0.63	0.72	0.67	0.77
H	0.77	0.77	0.75	0.72	0.71	0.56	0.62	0.68	0.78

[a] Percent similarity = beta measure of similarity:

$$PS = \frac{2 \Sigma \min (n_{1i}, n_{2i})}{N_1 + N_2}$$

, where N_1 and N_2 are the total importance values and n_{1i} and n_{2i} the numbers of the ith species in the two samples 1 and 2 respectively.

Table IV-16. The mean number of curlews seen and the mean heights of vegetation are negatively correlated during almost every time period.

	Period of Breeding Season	r^1	p
1977	Brood-rearing	-0.92	$\leq$0.001
1978	Pre-laying	-0.86	0.01
	Laying	-0.90	0.01
	Incubation	-0.97	$\leq$0.001
	Brood-rearing	-0.38	N.S.
1979	Pre-laying	-0.93	$\leq$0.001
	Laying	-0.90	$\leq$0.001
	Incubation	-0.80	0.02
	Brood-rearing	-0.83	0.01

[1] df = 6, The data fit an exponential correlation better than either a linear or power correlation. All r values are for exponential correlations.

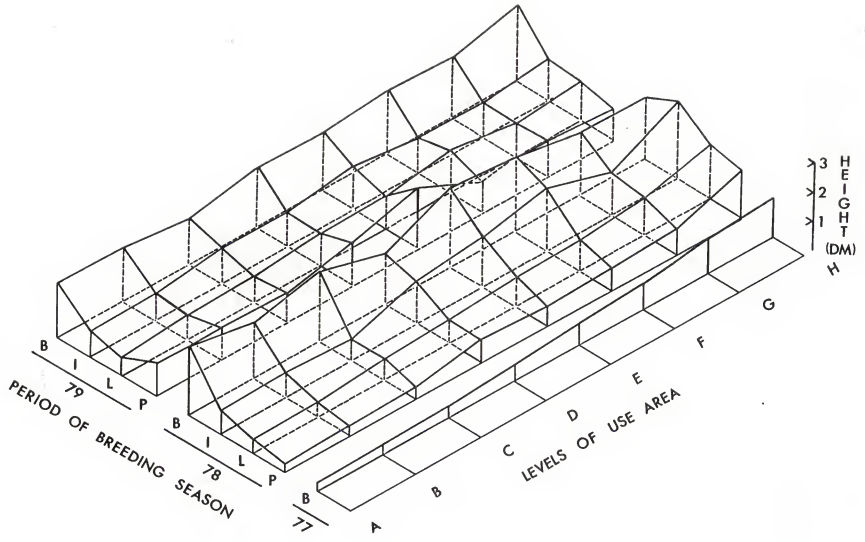


Fig. IV-6: Mean vegetation height for each "level of use" area on the BCPU for each period of the breeding season is different for each year and differs between kinds (Appendix Table IV-2).

Table IV-17: The mean number of curlews seen and percent vertical coverage of vegetation are negatively correlated* during almost every time period (see Appendix Table IV-3 for data).

Year	Period	Distance from vision board (m)									
		5		10		15		20		25	
		r	p	r	p	r	p	r	p	r	p
1977	Brood-rearing	-0.92	0.001	-0.82	0.01	-0.78	0.02	-0.73	0.05	-0.70	0.05
1978	Pre-laying	-0.93	0.001	-0.87	0.01	-0.82	0.01	-0.77	0.05	-0.85	0.01
	Laying	-0.89	0.01	-0.66	0.05	-0.82	0.02	-0.78	0.02	-0.84	0.01
	Incubation	-0.80	0.01	-0.68	0.05	-0.56	N.S.	-0.11	N.S.	-0.01	N.S.
	Brood-rearing	-0.91	0.001	-0.69	0.05	-0.53	N.S	-0.72	0.05	-0.75	0.05
1979	Pre-laying	-0.80	0.01	-0.86	0.01	-0.82	0.01	-0.84	0.01	-0.92	0.001
	Laying	-0.81	0.02	-0.70	0.05	-0.74	0.05	-0.84	0.01	-0.75	0.05
	Incubation	-0.65	N.S.	-0.79	0.02	-0.70	0.05	-0.64	N.S.	-0.53	N.S.
	Brood-rearing	-0.76	0.05	-0.93	0.001	-0.90	0.01	-0.62	N.S.	-0.48	N.S.

* All data were subject to exponential transformation, d.f. = 6 for each correlation coefficient.

Table IV-18. Ranges of % vertical coverage measurements for the four types of vegetative homogeneity on the BCPU.

Four types of vegetative homogeneity	% Vertical coverage at each distance (m)				
	5	10	15	20	25
Homogeneously short	0-25	10-35	20-45	30-55	35-65
Homogeneously tall	25-50	35-60	45-70	35-80	65-100
Generally short interspersed with tall and wide growth forms	0-50	25-75	35-100	45-100	55-100
Variably tall and dense	25-100	50-100	75-100	75-100	75-100

(see Grazing) tended to maintain the vegetation in this homogeneously short condition in the areas that supported more curlews. Rainfall, edaphic factors and disturbances all influenced the growth form association of any given area.

The above relationships between the mean number of curlews and vegetation height and vertical coverage indicate that curlews breed in those areas with the shortest, most homogeneous stands of vegetation. Additionally, areas A and B, which supported over half of the curlews on the BCPU, were characterized by the lowest vertical coverage values as measured from the furthest distance during both of the pre-laying periods 1978 and 1979.

In general, the strengths of the negative exponential correlations between mean number of curlews and vertical coverage of vegetation decreased as distance at which the measurement was taken increased. This was due to the introduction of more vegetation between the observer and the vision board and was important primarily as a description of the homogeneity of the vegetation growth form. Curlews may be more responsive to vegetation stature at 5 meters than at 25 meters, but the data are not of sufficiently fine grain to allow us to make that conclusion.

At the next finer grain of use and non-use analysis we found that curlew numbers were not evenly distributed amongst the 30 vegetation types of the BCPU. Some vegetation types provided more suitable habitat for curlews than others. Over half of the curlews observed from pre-laying 1977 through brood-rearing 1979 (Table IV-19) were in four of the 30 vegetation types (12, 1, 28, 15) and 95% of all curlews observed were in 12 of the 30 vegetation types (Table IV-19). The mean number of curlews observed in each vegetation type per year and the size of each type are positively correlated ($r = +0.73$, $p \leq 0.001$, $df = 28$). Although large vegetation types supported more curlews than smaller types, many types of similar size did not attract similar numbers of curlews. Density of curlews per vegetation type correlates closely with the mean number of curlews observed per vegetation type (Table IV-20). Although density would appear to reflect degree of use more accurately than numbers, curlews use only small portions of each of the 30 vegetation types.

Although a finer grain of analysis is necessary for describing curlew use quantitatively, patterns of variation in vegetation structure are most effectively handled at the level of the 30 vegetation types. Curlews apparently did not respond to plant species composition and plant species importance, at least as we have measured them. Curlews did respond to the vertical components of vegetation structure.

Vertical coverage of vegetation and mean number of curlews observed in each of the 30 vegetation types were significantly negatively correlated for all periods of the breeding season, brood-rearing 1977 through incubation 1978 1979 is probably due to the same factors described above for the more coarse grain evaluation (Table IV-21). Mean number of curlews per type correlated significantly with height of vegetation and with vertical coverage of vegetation at 5 meters for all periods of the breeding seasons 1977, 1978 and 1979 (Table IV-22).

Curlews were unevenly distributed amongst the 110 sections ($mile^2$) of the BCPU rangeland. The data for these 110 sections are presented in 10 arbitrary sets which represent large blocks of land referred to as "census

Table IV-19. Total number and percent curlews observed per vegetation type from 1977 to 1979, number is based on census sorted data only.

Rank	Vegetation Type	Total No. of Curlews Obs.	Percent of Curlews Obs.	Cum. Percent Curlews Obs.
1	12	1753	18.0	18.0
2	1	1408	14.4	32.4
3	28	1314	13.5	45.9
4	15	1045	10.7	56.6
5	14	949	9.7	66.3
6	27	697	7.1	73.4
7	22	673	6.9	80.3
8	21	542	5.6	85.9
9	7	493	5.0	90.9
10	9	166	1.7	92.6
11	3	132	1.4	94.0
12	24	130	1.3	95.3
13	6	104	1.1	96.4
14	23	80	0.8	97.2
15	16	71	0.7	97.9
16	8	49	0.5	98.4
17	2	47	0.5	98.9
18	4	44	0.5	99.4
19	10	26	0.3	99.7
20	26	13	0.1	99.8
21	20	10	0.1	99.9
22	19	5	0.1	100.0
23	5	0	0.0	--
24	17	0	0.0	--
25	13	0	0.0	--
26	11	0	0.0	--
27	18	0	0.0	--
28	25	0	0.0	--
29	29	0	0.0	--
30	30	0	0.0	--

Table IV-20. Density of curlews in the 30 vegetation types correlates with the number of curlews. Mean No. of curlews observed per year ($r_s = 0.80$, $p \leq 0.01$).

Vegetation Type	Hectares	Mean No. of Curlews Obs.	Density $\bar{x}$ No./Ha	Density Rank
12	2125.5	584.3	0.27	4
1	4545.9	469.3	0.10	8
28	2472.7	404.7	0.16	7
15	647.1	348.3	0.53	1
14	1223.4	316.3	0.26	5*
27	949.8	232.3	0.25	6
22	870.5	224.3	0.26	5*
21	647.9	180.7	0.28	3
7	413.2	164.3	0.40	2
9	845.4	55.3	0.07	9*
3	1015.4	44.0	0.04	12*
24	772.2	43.3	0.06	10
6	484.0	34.7	0.07	9*
23	621.2	26.7	0.04	12*
16	521.3	23.7	0.05	11*
8	354.1	16.3	0.05	11*
2	1086.2	15.6	0.01	14*
4	543.1	14.6	0.03	13
10	677.9	8.6	0.01	14*
26	690.0	4.3	0.01	14*
20	454.9	3.3	0.01	14*
19	773.7	1.7	0.01	15*
5	708.2	0.0	0.00	15*
17	359.4	0.0	0.00	15*
13	424.9	0.0	0.00	15*
11	550.0	0.0	0.00	15*
18	765.3	0.0	0.00	15*
25	677.1	0.0	0.00	15*
29	159.5	0.0	0.00	15*
30	571.4	0.0	0.00	15*

* = ties

Table IV-21: Mean vertical coverage and average number of curlews are negatively correlated during every phase of the breeding cycle except for the brood-rearing periods of 1978 and 1979.

Period of Breeding Season		5 Meters	
		r^1	p
1977	Brood-rearing	-0.88	$\leq$0.001
1978	Pre-laying	-0.90	$\leq$0.001
	Laying	-0.86	$\leq$0.001
	Incubation	-0.68	$\leq$0.001
	Brood-rearing	-0.29	N.S.
1979	Pre-laying	-0.81	$\leq$0.001
	Laying	-0.72	$\leq$0.001
	Incubation	-0.44	0.02
	Brood-rearing	-0.25	N.S.

1, df = 28, all correlations are exponential.

(Percent vertical coverage values for all types during each period of the breeding seasons 1977-1979 are presented in Appendix Table IV-4.)

Table IV-22: Mean vegetation height is negatively correlated with mean number of curlews in every phase of the breeding cycle except for brood-rearing periods 1978 and 1979.

Period of Brood-rearing		Correlated Vegetation Height and Curlew Numbers	
		r^1	p
1977	Brood-rearing	-0.66	$\leq$0.001
1978	Pre-laying	-0.58	0.01
	Laying	-0.41	0.05
	Incubation	-0.38	0.05
	Brood-rearing	-0.21	N.S.
1979	Pre-laying	-0.49	0.01
	Laying	-0.42	0.05
	Incubation	-0.39	0.05
	Brood-rearing	-0.25	N.S.

1, df = 28, all correlations are exponential.

blocks" (see section on population dynamics). For each section within these blocks we calculated the mean number of curlews observed per census for each period of the breeding seasons 1977 through 1979 and the number of curlews observed per kilometer traveled during formal censusing of the BCPU (see grazing section). We tested for significant changes in the mean number of curlews observed in each section through 1977-1979 by analysis of variance (ANOVA). Because we have no reason to believe these data are normally distributed, we also tested those data for significant change in number of curlews observed using the non-parametic Kruskal-Wallace ANOVA. Both tests yielded comparable results.

Within each year the mean number of curlews observed within each section generally increased from pre-laying through the incubation period followed by a slight decrease in curlew numbers during the brood-rearing period. This pattern of variation was only partially due to variation in curlew use. Variation in detectability between different phases of the breeding season was probably most responsible for this pattern. The slight decrease in the mean number observed during brood rearing was due to two phenomena. Many curlews which were unsuccessful early in their breeding attempts apparently left the BCPU rangeland. Additionally, some females of successful pairs had already left the BCPU by this time. Because curlews were much more detectable during brood rearing than at other times our census figures don't adequately reflect the real decrease in numbers for this period.

The BCPU varies greatly in topography, most conspicuously in steepness. Because topography influences visibility and hence predator detection, it is potentially important to the curlews. We quantified the steepness of the topography within each section by calculating the horizontal distance (mean number of meters/24) between 20 foot (6.1 meter) contour intervals (Figure IV-7). Five samples per section were obtained along randomly placed transects on USGS topographic maps (7.5 minute series). Multiplying the mean values per section in Fig. IV-7 by 24 gives meters of horizontal distance. Thus a value of 5.0 translates to a rise of 6.1 m every 120 m or a slope of 5%. Sections with lower mean values have steeper topography.

The average distance between 6.1 meter contours over the entire BCPU is 98.8 ± 74.0 meters (95% confidence interval). Topographic steepness is continuously variable but the distribution of this habitat variable is skewed slightly to the steep end of the continuim (Figure IV-8).

Curlew numbers were negatively and significantly correlated as a power function with the steepness of the topography on the BCPU ($r = -0.21$, $p = 0.05$, $df = 108$).

We found no significant correlations between curlew numbers and the mean number of meters above sea level per section, the mean number of hectares of terrain facing any of the four major compass directions, nor the amount of relatively flat terrain per section as measured by the mean number of hectares of 10% slope or less per hectare.

At the finest grain of analysis we evaluated the use of topography and vegetative characteristics of habitat by individual curlews by employing an activity budget sampling procedure (fixed-interval, instantaneous sample, Altmann 1974). It was impossible to color band each individual curlew

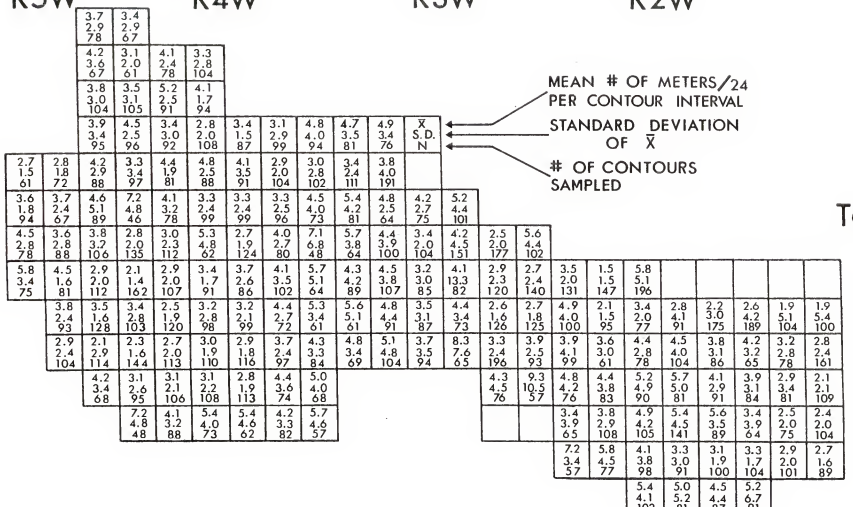


Fig. IV-7: Relative steepness of the 110 sections on the BCPU.

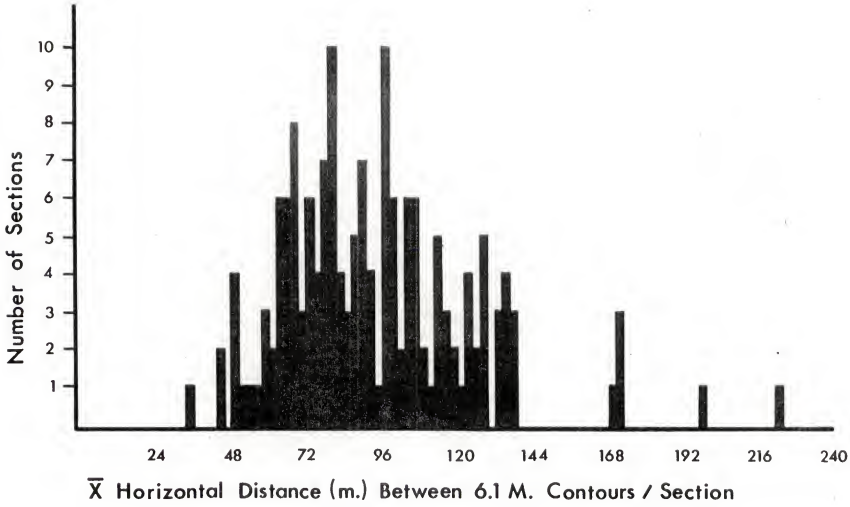


Fig. IV-8: Distribution of topographic variation on the BCPU expressed as a mean number of meters horizontal distance between 6.1 meter (20 feet) contour intervals.

breeding on the BCPU and hence impossible to devise a truly random sampling scheme for activity budget sampling. We employed a Sheffe matrix to organize the rotation of census blocks in which we observed focal animal such that we observed birds in different areas and different times of the day throughout the 1979 breeding season. In addition we observed individual curlews in different portions of each area during each sampling period to minimize the probability of observing the most conspicuous individuals using each area of the BCPU. Thus our sample represents the closest possible estimate of an independent sample short of a random sample derived from a population in which all birds are individually recognizable. For 1979, we have 229 observation periods of from one to three hours each; 50 of these were for females and 170 were for males. All daylight hours were included. We noted at 2 minute intervals the location of the focal animal on the topography (on the hilltop, the top quarter of the hill, midslope, the bottom quarter of the hill, flat expanse or drainage between hills). We also assessed the height of the vegetation nearest the curlew and the vertical coverage of the vegetation directly adjacent to the focal animal. We obtained 2,637 observations for each of these parameters.

Male and female curlews used topographic features of the BCPU in superfically similar ways during all but the incubation period 1979 (Figure IV-9). The use of topography by both sexes differed significantly from random during the pre-laying, laying and incubation periods of the 1979 breeding season (all χ^2 values in this section are based on count data, Table IV-23). Observations of use of topography by males but not by females deviated significantly from random, during the brood-rearing period 1979. The female data for brood-rearing 1979 was arranged into 4 categories: hill top, slope, bottom drainage and flat to allow for appropriate statistical testing. We observed curlews to use hilltops and flat expanses of terrain significantly more often than any one portion of slopes during incubation and brood rearing ($t = 2.6$, $p = 0.01$), but they do not use hilltops and flat significantly more than all slopes combined ($t = 0.025$, $p = 0.49$).

Curlews may use hilltops during the latter periods of the breeding season because it is easier to observe their brood and maintain anti-predatory vigilance from such places. The increase in frequency of observations of adult curlews in flat expanses may be due to adult curlews locating themselves and their broods in response to variable prey densities. It is clear that topography is important. Curlews distribute themselves differently during pre-laying and incubation than during incubation and brood-rearing. These differences parallel the increases in anti-predator behavior described earlier.

The coarse grain analyses of habitat all suggest that curlew numbers and the vertical components of vegetation were related. We used the activity budget data to test the hypothesis that curlew use of vegetation was random with respect to vegetation height and vertical coverage. We calculated the percent occurrence of male and female curlews in vegetation at each height category from 0.0 to 3.5 dm for each period of the breeding season in 1979 (Figure IV-10). We also calculated the percentage of observations of vegetation height in each of these categories for each period of the breeding season (Figure IV-10). We used these percentages to calculate expected values of curlew observations in each height category. Data for females during brood-rearing was combined into three categories for statistical testing.

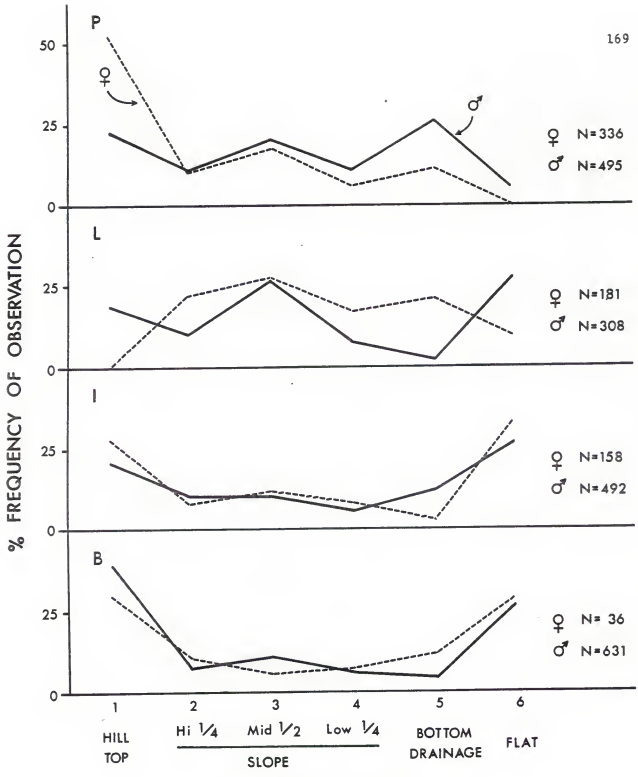


Fig. IV-9: Long-billed Curlew males (solid lines) and females (dotted lines) use different topographic features in similar ways. Notice the change in use during incubation (I) and brood-rearing (B) compared to pre-laying (P) and laying periods (L).

Table IV-23: Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to topography during almost all phases of the reproductive cycle 1979.

Phase	Sex	(N)	x^2	df	P
Pre-laying	Males	(495)	52.5	5	$\leq$0.001
	Females	(336)	103.8	5	$\leq$0.001
Laying	Males	(308)	47.5	5	$\leq$0.001
	Females	(181)	39.6	5	$\leq$0.001
Incubation	Males	(493)	30.2	5	$\leq$0.001
	Females	(158)	24.9	5	$\leq$0.001
Brood-rearing	Males	(631)	89.5	5	$\leq$0.001
	Females	(36)	4.0	3	0.30

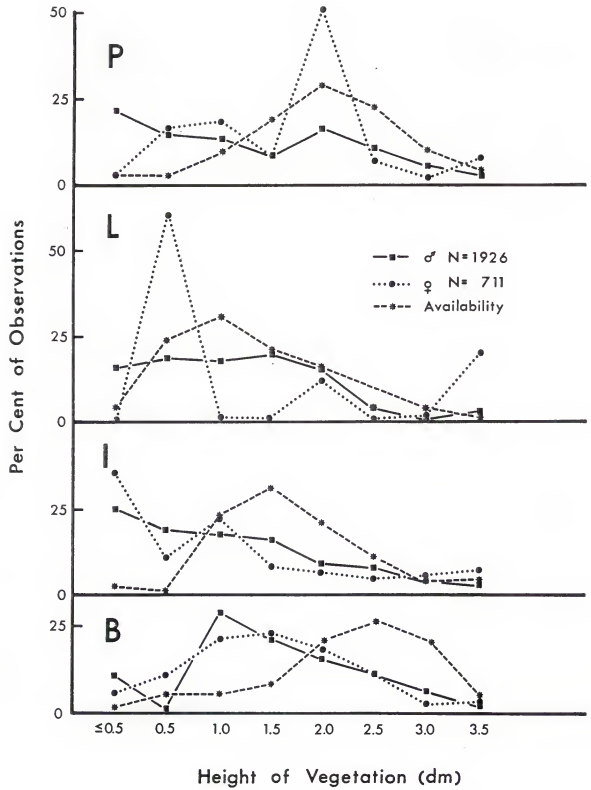


Fig. IV-10: Percent occurrence of curlews in vegetation by height category compared to availability, 1979.

Male and female curlews did not distribute themselves randomly in relation to the availability of vegetation height categories (Table IV-24). Male curlews used vegetation of 0.0 to 1.0 dm height significantly more than expected during the prelaying period, and they used taller vegetation significantly less than expected. Male curlews made equal use of vegetation at all heights between 0.0 and 2.0 dm height during the laying period. We saw males much more often than expected in vegetation 0.0 dm. Male curlews continued to prefer short vegetation during the incubation and brood-rearing periods when they occurred at higher than expected frequencies in the shorter categories and lower than expected frequencies in taller height categories.

Female curlews did not use the available height categories in the same way as males during the pre-laying and laying periods. Frequencies of female curlew observations were nearly equal to expected values in the 0.0 and 3.5 dm height categories but were substantially higher in the 0.5, 1.0 and 2.5 dm categories during pre-laying. During laying females occurred more frequently in vegetation at 0.5 and 3.5 dm and less frequently at all other heights than expected. The frequency distributions of female curlews more closely resembled the availability curves for the pre-laying and laying periods than those for males, and females were substantially more variable in their use of the available height categories than were male curlews. However, during incubation and brood-rearing, female use of vegetation was very similar to that of males. Females occurred at a higher frequency in shorter height categories and lower than expected frequency in taller height categories.

Seasonal changes in the vegetation height availability curves are due to disturbance of the vegetation by grazing and growth of the vegetation. The relatively high frequency of vegetation 2.0 to 2.5 dm tall during the pre-laying period is due to residual vegetative biomass remaining on the BCPU from the 1978 growing season. The disappearance of this tall vegetation was caused by the introduction of sheep and cattle. The progressive shifts in the mode of height availability during incubation and brood-rearing to the taller end of the continuum reflects the increase in height of vegetation as the plants progressed through the seasonal succession. It was apparent that neither male nor female curlews track the shift in the mode of height availability. Curlews used the short end of the height category continuum much more frequently than the tall end relative to the availability of each height category.

We also tested the hypothesis that curlews use vertical coverage densities randomly. We calculated percent frequency of observations of male and female curlews in six vertical coverage classes (Figure IV-11) and compared them with the percent frequency of observations of vertical coverage in each of these categories for each period of the breeding season. These expected values were based on the percent availability of each vertical coverage class for the entire BCPU at each period of the breeding season. Vertical coverage categories for female observations during the brood-rearing were combined to allow appropriate statistical testing.

Male and female curlews did not use the six available vertical coverage categories randomly during any period of the breeding season (Table IV-25). During pre-laying males and females occurred at substantially greater frequencies than expected in the lower vertical coverage categories and at

Table IV-24: Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to height of vegetation during any phase of the reproductive cycle in 1979.

Phase	Sex	(N)	x^2	df	P
Pre-laying	Males	(495)	147.6	7	0.001
	Females	(336)	97.0	7	0.001
Laying	Males	(308)	50.4	7	0.001
	Females	(181)	148.9	7	0.001
Incubation	Males	(493)	242.7	7	0.001
	Females	(158)	105.8	7	0.001
Brood-rearing	Males	(631)	321.6	7	0.001
	Females	(36)	17.1	2	0.001

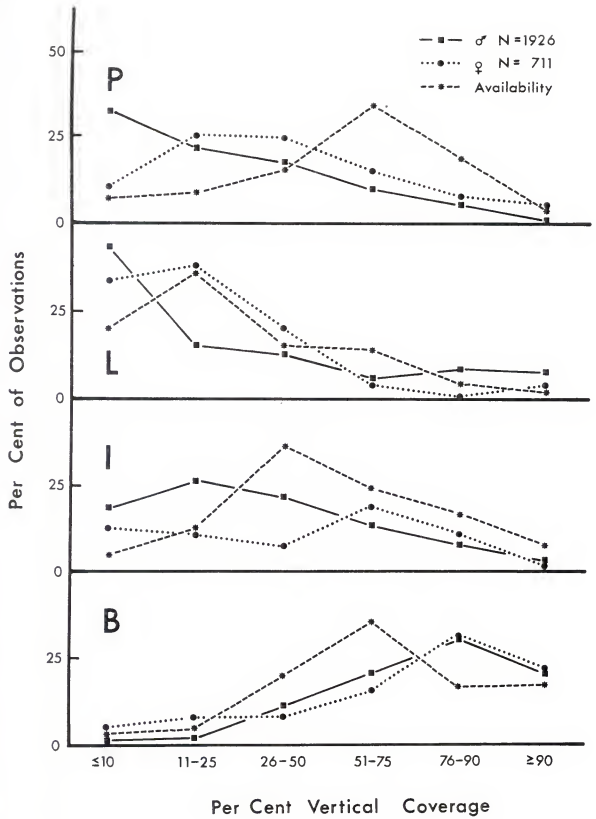


Fig. IV-11: Percent occurrence of curlews in relation to vertical coverage values compared to availability, 1979.

Table IV-25: Neither male nor female adult Long-billed Curlews distributed themselves randomly with respect to vertical coverage of vegetation during any phase of the reproductive cycle in 1979, except for females during the brood-rearing phase.

Phase	Sex	(N)	x^2	df	P
Pre-laying	Males	(495)	227.5	5	0.001
	Females	(336)	80.2	5	0.001
Laying	Males	(308)	91.4	5	0.001
	Females	(181)	36.9	5	0.001
Incubation	Males	(493)	129.3	5	0.001
	Females	(158)	23.3	5	0.001
Brood-rearing	Males	(631)	110.6	5	0.001
	Females	(36)	0.99	1	0.7

substantially lower than expected frequency in the higher vertical coverage categories.

During incubation males used, more frequently than expected, the $\leq$ 10 and 11-25% coverage categories and used the remaining categories less frequently than expected. Similarly, females used only the $\leq$ 10% coverage category more frequently than expected.

Both male and female curlews reversed their use of vertical coverage during brood-rearing. Males occurred more frequently than expected in only the 76-90 and $\geq$ 90% coverage categories during this period. Females occurred more frequently than expected in all coverage categories except 26-50 and 51-75%. The conspicuous reverse in curlew use of vertical coverage continuum during the brood-rearing period is most likely an expression of preferred chick habitat. Broods and individual chicks were nearly always located in 76 to $\geq$ 90% coverage categories. The use of areas with high vertical coverage provide the chicks with anti-predatory, thermoregulatory, and foraging benefits.

Curlew chicks have a different set of habitat requirements than do breeding adult curlews. Curlew chicks require an abundant invertebrate prey base. As long as there is no direct disruption of the invertebrate population currently using the BCPU rangeland there is no reason to predict any lack of food for curlew chicks in the future.

In addition curlew chicks require a different vegetation structure than adult curlews. Curlew chicks need small tall dense stands of vegetation or frequent bunch grasses (about 5% of the total vegetation structure). These are used by chicks as refugia to escape potential predators and/or heat during the very hot dry periods of the brood-rearing period. Even when these habitat characteristics are available, mortality of curlew chicks is very high.

The BCPU appears to provide the minimum amount of chick rearing habitat necessary to fledge enough chicks to match adult mortality.

Curlew chicks require prey rich stands of tall ($\geq$ 2 dm) vegetation in which to forage and escape potential predators. These areas need not be large but only a fraction of a hectare in size to provide an effective anti-predator refugia.

Characteristics of curlew breeding habitat on the BCPU can be summarized simply: (1) vegetation between 0.0 and 1.0 dm tall during the pre-laying through incubation periods, but vegetation up to 2.5 dm can be tolerated during brood-rearing; (2) vertical coverage values between 0 and 50% from pre-laying through incubation and between 76 to 100% during brood-rearing. Furthermore this vegetation must occur on moderately rolling topography with elevation change of 6.1 m (20 feet) every 98.8 $\pm$ 71.0 meters; (3) it must be surrounded by at least 1/4 mile of similarly suitable habitat which acts as a buffer against disturbance. Direct disturbance of the habitat or breeding adults must be minimal unless the disturbance directly or indirectly increases the suitability of the area or increases the probability of breeding success.

CHAPTER V

MANAGEMENT OF LONG-BILLED CURLEWS ON THE BCPU

In this chapter we discuss those qualities of the BCPU that are important to Long-billed Curlews and discuss the effects of changing current management practices on future use of the BCPU by breeding curlews. The BCPU is presently a multi-use area and it is not our intention to recommend any management changes. However we can forecast with considerable precision what the impact of such changes would be on curlews and can predict the consequences of various changes on the curlew population. The ultimate decision as to the relative importance that should be attached to the curlews in planning the use of the BCPU is not ours to make.

The breeding distribution and abundance of Long-billed Curlews in western North America is poorly understood (Allen 1980; McCallum 1977; Jurek and Leach 1977; and Palmer 1967). In a recent attempt to evaluate the status of Long-billed Curlews in the Columbia and northern Great Basins of the United States, Pampush (1980) estimated that the annual grasslands of the central Snake sub-basin of western Idaho and eastern Oregon support approximately half of the entire regional (5 state) breeding population of Long-billed Curlews (which also means half of the curlews breeding west of the Continental Divide). Pampush furthermore considered the BCPU population to be the nucleus for the central Snake sub-basin. Between a third and a half of the curlews estimated to breed within this sub-basin do so on the BCPU (Pampush 1980). Therefore between 20 and 25% of the entire breeding population of Long-billed Curlews in the upper Columbia and northern Great Basin region currently nest on the BCPU. Clearly, this area is the most important discrete breeding ground for Long-billed Curlews west of the Rocky Mountains, and perhaps is rivaled only by the Sand Hills of western Nebraska in overall importance.

The implications of these findings alone suggest that serious consideration should be given the possibility of managing all or parts of the BCPU specifically for Long-billed Curlews. Although we do not discuss the possibility here, the establishment of a formalized "refuge" and managing the area exclusively for the benefit of curlews needs serious consideration. Surprisingly such management does not involve "locking up" the BCPU; multiple use would be possible. Grazing especially is necessary to the curlews and would have to be included as a management technique. Recreation, outside the curlew breeding season, and/or off the nesting habitat and "buffer-zones" is not necessarily detrimental to the curlews unless it alters the habitat.

Why is the BCPU so attractive to Long-billed Curlews? Very few wildlife species make any use of the BCPU but it is obviously highly preferred habitat for curlews. If we can understand why the BCPU is attractive we can understand how various management regimes will affect the curlews.

Of underlying importance are important structural similarities between the habitats used by curlews during the breeding and non-breeding seasons. This report has stressed the strong preference shown by breeding curlews for extremely short vegetative cover. But curlews spend only 3-3 1/2 months of each year on the BCPU and their other upland breeding grounds. They spend them remainder of the year on the intertidal zone along coastlines, bays, estuaries,

deltas, etc. (Stenzel et al. 1976); around large inland water bodies such as the Salton Sea (McCaskie 1970); as well as in open marshlands and fallow croplands (Manolis and Tangren 1975). During the entire year Long-billed Curlews are found only on open, bare areas or where the vegetation at any time of the year is open and shorter, usually less than 30 cm in height. Why is this so?

Thick vegetative cover severely encumbers an adult's ability to move its head and bill and therefore encumbers its ability to feed. Because curlews do not appear to need long bills for feeding at any time on their breeding ground, we contend that curlews are restricted to open breeding habitats (vegetation height not exceeding 30 cm) primarily because of structural adaptations for feeding during the remainder 8 1/2-9 months of each year. Generally, curlews are limited to open, two dimensional types of habitats because of their very long bills (The over-riding importance of vegetative height and density was demonstrated vividly during June of 1978 when vegetation on the BCPU became exceptionally tall and dense. Adult curlews abandoned their chicks earlier than usual and none of the radio-instrumented chicks survived).

Not only must the vegetative cover allow the adult curlews to feed there, it must also support adequate invertebrate food resources for them upon their arrival, and later for their chicks as well. In some years food resources may be inadequate or less accessible to adults when they arrive (e.g. as a result of snow cover or heavy residual vegetation). When this occurs, the adults may not disperse over their breeding grounds, but rather they may forage in flocks at localized food patches. In March and April, 1979, many adult curlews fed on freshly plowed fields, irrigated pastures, and other agricultural lands near the BCPU.

Curlew chicks, however, cannot rely either on such patches or on their parents for foods. They must reach an area containing food and learn to feed themselves effectively within 3-4 days of hatching or else perish. Thus, an open area which does not produce food resources for curlew chicks with at least some annual and seasonal regularity cannot support breeding curlews. Grasshopper eruptions provide this important food resource for curlews on many short grass rangelands including the BCPU. Control of grasshoppers would reduce the quality of the habitat for curlews and may cause secondary poisoning.

Given the habitat and vegetative cover requirements of Long-billed Curlews, there is no alternative to their ground nesting. Adult curlews have elaborate anti-predator behaviors, some of which involve cooperation between neighbors. However, where mammalian carnivores and/or canids exist at high densities, these behaviors are not effective and nest losses may be very high. On the BCPU, predator control programs undoubtedly have benefited curlew nesting success in the recent past.

Adult curlews are very wary of humans during the breeding season, and they respond to human intruders as potential predators. For most of the year adult curlews avoid close contact with humans and withdraw or flee from direct harassment or disturbance. However, during brood-rearing (May and June) parental adults aggressively mob intruding humans by "dive-bombing" and flying straight at them, veering away at the last moment. This "bizarre" behavior makes them highly vulnerable to harassment and shooting. This poses a special threat to the viability of any breeding population, but especially to curlews which are potentially very long-lived (20-30 years) with a very low net

reproductive rate. The probability of any single curlew egg surviving and the chick growing to an adult that can reproduce itself is extremely low; but once mature, a female can be expected to lay 40 or more fertile eggs over 10 or more seasons, if she can avoid being shot. A breeding population can tolerate shooting of flocking juveniles in July and August much better than it can the shooting of mature adults, either in Mexico during the winter, or on the breeding grounds during brood-rearing as occurs on the BCPU. Winter shooting as occurs in Mexico may have an important impact on North American curlews but we have no insight into the importance of this problem.

Human disturbance of curlews appears to be relatively light over most of the BCPU. This may be a result of the bird's general wariness and their maintenance of a well-defined "buffer zone" (approximately 0.4 km (1/4 mile) wide) between areas of human use and the curlews' own use areas. Unfortunately, however, almost all human-curlew interactions are destructive or damaging to the birds in some manner. Furthermore, the trend seems to be toward more of these interactions as the human population expands around the BCPU.

In summary, Long-billed Curlews are attracted to the BCPU because:

1. vegetation is extremely short but supports a food base (insects and spiders) for adults and for chicks;

2. predation pressure has been within tolerable limits on both eggs and adults;

3. human disturbance and development have been relatively slight over large continuous blocks of suitable habitat;

4. the curlews can meet all their requirements for breeding: suitable places to court, nest, rear their young, stage prior to departure, feed, escape summer heat, either on the BCPU rangeland itself or on a combination of BCPU rangeland and nearby agricultural lands.

Some of the characteristics of the BCPU that limit the number and success of curlews attempting to breed there can be altered or at least managed. These manageable constraints can be divided into two general categories: 1) those related to dynamics of curlew breeding habitat, that is the short grass rangeland habitat; and 2) those which directly affect survival of individual curlews and the success of their breeding attempts, but which are unrelated to habitat dynamics.

The BCPU rangeland is not uniformly suitable for use by breeding curlews, and suitability of any particular part of it may change from year to year or even within a single season depending on climate, grazing, fire, etc. Curlews localize their behavior in short vegetation (less than 30 cm) with low vertical coverage values. It is availability of this kind of vegetation that determines whether curlews will breed in a specific area or not.

Two factors contribute to the vertical component of vegetation - growth of the current year's plants which results in increased height and vertical coverage, and secondly, residual vegetative biomass from the previous growing season. Growth of current year's vegetation is necessary for all animals

using the BCPU; it also provides a food base for insects which are prey for curlews. However, it is a potential constraint on curlew breeding depending on the height and vertical coverage value it achieves during the growing season.

Residual vegetative biomass decreases curlew habitat suitability. It creates visual barriers which inhibit communication and predator detection. Additionally, residual vegetative biomass inhibits brood-movements and foraging by both chicks and adults depending on its density and horizontal distribution. It is of little value for cover; it does not provide a moist, cool microclimate about itself the way living plants do and hence it is of little value for facilitating thermoregulation of chicks.

Certain portions of the BCPU rangeland are unsuitable for use by breeding curlews. Areas dominated by sagebrush, crested wheatgrass, or warm season forbs are rarely used by curlews because of their characteristically tall vegetation (>30 cm) and high vertical coverage values. Relict sagebrush stands are not extensive on the BCPU. Crested wheatgrass plantings, however, already cover several large areas of the BCPU, and unless post-fire practices which prescribe immediate reseeding to this species (or any other plant species with high growth form and coverage characteristics) are curtailed, there will be further losses of suitable curlew breeding habitat.

The plant species succession which follows a fire may increase or decrease the suitability of an area for use by breeding curlews. Post burn vegetation is often dense, tall, composed of warm season forbs, and unsuitable for use by breeding curlews. However, depending on the seed source, and grazing intensity the following spring some post-burn vegetation may be within the range of tolerance of breeding curlews. In any event, the immediate effects of fire are greatly modified within a few years.

Grazing in general benefits curlews. Sheep and cattle are both capable of grazing the vegetation down to a height and density that is acceptable to curlews, and both remove residual vegetative biomass. Although grazing by either class of livestock makes the habitat more suitable for curlews, sheep are more effective than cattle.

Most of the constraints that affect curlews directly are related to human activity on or near the BCPU. The most frequent human activities on the BCPU are ORV use, shooting of firearms, littering, or (usually) some combination of the three.

Off-road vehicle travel on the BCPU is an insidious constraint on the curlew population. ORV tracks render portions of the BCPU unsuitable to breeding curlews by denuding the substrate of vegetation and therefore facilitating topsoil erosion. ORV's are also a potential threat to curlew chicks and eggs. Although the probability of running over a nest or chick is low, it does occur with some frequency. Chicks and eggs are cryptically colored and impossible to see from a moving vehicle. Restriction of vehicles to existing roads and trails would minimize the direct loss of nests and chicks. During brood-rearing curlews respond to an ORV as if it were a predator. Hence, the persistent presence of ORV's in suitable curlew habitat may stress the birds to the point of abandonment of territory, nest, or chicks. Unrestricted ORV use on the BCPU will almost certainly lead to further habitat losses to and

physical destruction of Long-billed Curlews. The problem is compounded by the fact that much of the littering and shooting are associated with a small proportion of the ORV use.

It is unfortunate that in late May and early June (especially Memorial Day weekend), when climatic conditions on the BCPU are most conductive to human use, the curlews are especially vulnerable to shooters. Use of firearms on the BCPU must be controlled during this period.

Littering may be the most insidious human activity affecting curlews breeding on the BCPU because of the wide variety of its destructive effects:

1. it provides visual barriers to curlews attempting to breed;
2. it provides refugia for curlew predators;
3. curlews may injure themselves on sharp metal, broken glass, ensnaring wire, etc.;
4. it eliminates a substantial amount of habitat from the available useable area;
5. it invites more litter; and
6. it attracts shooters.

Absolutely no benefit accrues to curlews by littering.

The BCPU supports relatively few predators of curlews; however, they are of considerable influence on the curlew breeding population. Canids and badgers are the most frequent predators of eggs. Raptors are the most frequent predators of chicks, but they rarely prey on adult curlews. Domestic cats probably prey on some of the chicks that move from the rangeland into alfalfa fields. Although elimination of all predators from the BCPU is impractical, coyotes and badgers are serious nest predators and their numbers can and should be closely controlled. Feral dogs and cats should be removed and their refugia destroyed. No additional raptor nest structures should be placed on, or moved around the BCPU to encourage their breeding. Poisoning rodents in an attempt to reduce predator numbers would have no more than short term effects because of the high reproductive rate of rodents. Direct management of the predators would be more effective.

Curlews are habitat limited; their numbers will increase on the BCPU if the amount of suitable habitat is increased. Conversely, their numbers will decrease if the amount of suitable habitat is reduced. In order to maintain and/or improve curlew breeding habitat on the BCPU, it is necessary to maintain vegetative cover with a low vertical component. All other management possibilities are irrelevant if low profile vegetation cannot be maintained. If vegetation can be maintained the next most important management technique would be to manage those factors that directly affect curlews and their reproductive success. Curlew chicks require a different set of habitat requirements than do breeding adults. The chicks are frequently found in association with Giant wild rye clumps which make up a small proportion of the vegetation. These clumps may serve three functions to curlew chicks; refugia from

predators, shade source for thermoregulation and abundant grasshopper food supply.

The areas of the BCPU that curlews use most heavily lay along the stock driveways which crisscross the study area and are heavily grazed by sheep. Sheep grazing is very beneficial to curlews and an increase in sheep allotments and stock driveways grazed by sheep should increase the amount of top quality curlew habitat and result in an increase in the breeding population of curlews on the BCPU.

The establishment of a minimum number of campsites by sheepherders would reduce the small but inevitable loss of nests near their campsites. Sheepherders working alone tend to move their camp more frequently while sheepherders working in pairs move less often and establish fewer campsites.

All grazing of livestock on the BCPU is beneficial to curlews because it minimizes the vertical components of the vegetation. Manipulation of grazing formulas to reduce the vertical component of the vegetation prior to the curlews arrival or early in the breeding season and to maintain a short homogeneous stand through incubation would increase habitat suitability wherever this management technique is applied. Rest rotation cattle grazing has the potential to produce high quality curlew habitat if stocking rates are high during the winter and fall.

The size of the curlew breeding population on the BCPU is directly limited by the amount of suitable breeding habitat available to the birds during the breeding season. Any activity that reduces the amount of habitat will cause a decline in the population. Agricultural conversion, residential development and re-seeding areas with crested wheatgrass all reduce the amount of habitat available to breeding curlews.

Some cultivated areas are used by curlews during portions of the breeding season. Alfalfa fields may be especially beneficial as curlew foraging and loafing areas during the brood-rearing period of the breeding season. However, the human activities which take place in and around these agricultural fields are often detrimental to curlews. The conversion of short grass rangeland to agricultural use reduces the amount of habitat available to nesting curlews; increases the potential for curlew-human interaction, and reduces their numbers.

Similarly, conversion of short grass rangeland to residential developments eliminates curlew habitat and brings humans and curlews closer together. Curlews respond to this juxtaposition by avoiding use of areas closer than approximately 0.4 km from human development and activity establishing a "buffer zone" between themselves and the potential human predator (and his dogs, cats, and vehicles). Additional residents would also direct their recreational activities toward the adjacent rangeland. To protect the curlews additional rangeland on the BCPU should not be converted to residential areas and the negative effects of conversions of private enclaves should be minimized by controlling access by these new residents to the adjoining rangeland.

Crested wheatgrass plantings are of no benefit to curlews (nor to other wildlife using the BCPU). This management regime has already limited a substantial amount of otherwise suitable nesting habitat from that available to

curlews. Conversion of existing crested wheatgrass plantings to short grass range similar in vertical structure of vegtation on stock driveways would make these areas suitable for use by breeding curlews. There is also a temptation to seed crested wheatgrass into burned areas. We suggest that crested wheatgrass not be planted, but that the BLM return burned areas to a habitat type suitable for curlews.

Vegetative cover on the three areas of the BCPU most heavily used by curlews averaged: Cheatgrass brome (Bromus tectorum) 45%; Medusahead wildrye (Taeniatherium asperum) 30%; Fetuca bromoides 10%; Bulbous bluegrass (Poa bulbous) 5; Sandberg bluegrass (Poa sandbergii) 5%; and Giant wildrye (Elymus cinereus) 5%. Heavy grazing of this mix of species provides suitable curlew habitat elsewhere on the BCPU. An alternative to crested wheatgrass should be sought by the BLM. If one of the natural associations found in western Nebraska where large numbers of curlews breed and which also provides excellent forage for cattle could be established at the BCPU, it would provide excellent forage for cattle and excellent curlew habitat. Of the three possible Nebraska associations that fit these criterion, Nebraska shortgrass prairie seems the most promising for the BCPU. Principle plant species in the association are:

Prairie sandreed	Calamovilfa longifolia
Tall western wheatgrass	Agropyron smithii
Tall needle and thread	Stipa comata
Blue grama	Bouteloua gracilis
Buffalo grass	Buchloe dactyloides
Prairie junegrass	Koeleria cristata
Scribner panicum	Panicum scribnerianum
Hairy grama	Bouteloua hisuta

This association exists in a portion of Nebraska that is similar to eastern Gem county, Idaho, in their soils, topography and climatic patterns. We suggest that it might be possible to graze this association at the rate of 2.0 to 3.0 acres/AUM.

The BCPU could be managed: to maximize curlew values at the expense of other interests, to maximize other values at the expense of curlew interests, to compromise all the values and interests on the BCPU.

We recommend certain management changes to be initiated immediately because they threaten all values on the BCPU. The fact that they would benefit curlews is secondary. First, the uncontrolled deposition of litter is an unacceptable activity on public land. The removal of litter and prevention of additional littering on the BCPU should be one of the major management concerns for the area. Swift and deliberate action should be taken to eliminate this problem on the BCPU. It has reached a crisis level on the North Dewey area.

Secondly, the unlimited availability of the entire BCPU to ORV use must be discontinued. The ORV use is gradually degrading the quality of the short grass rangeland and making it less suitable for grazing and wildlife and less aesthetically pleasing. Control of ORV use would also help reduce the littering and shooting problem. ORV "parks" which have been previously and spontaneously established on the BCPU would be excellent sites for the

localization of these activities. These areas proved attractive to ORV enthusiasts in the past and appear to have remained so. Conversion of these areas to ORV parks seems to provide for an equitable division of interests.

Thirdly, the shooting of curlews is illegal. The BLM must somehow see that the laws to protect curlews are enforced. Shooting should not be allowed on the rangeland during the curlew breeding season (approximately March 15 to August 15). Given the nature of the BCPU and the currently unrestricted use of the area, this is a real problem for the BLM. Perhaps an inter-agency, inter-government approach to these problems would lead to a helpful solution.

If the BLM decides to manage the BCPU primarily for the benefit of Long-billed Curlews, the Bureau should consider converting the area to a wildlife refuge of some kind of transferring management to some other agency that could manage it as a refuge. However, designation of the area as a refuge would be useful only if it allowed for a continuation of grazing which is essential to the long-term usefulness of the area to curlews. Also under such a system the BCPU could be improved as curlew habitat in ways already discussed.

Finally, if the BCPU is to be maintained as a multiple-use area with a balance of uses more-or-less similar to its present status, certain procedures should be followed or established to insure maintenance of the curlews. First and foremost of these the habitat must be maintained as a short grass rangeland and suitable vegetative cover maintained. The important role of grazing in maintaining the habitat in a suitable condition has already been discussed. Any conversion of this public land to private land and its subsequent development for any purpose will have dramatic, negative effects on the curlew population. The BLM is bound by law to protect and maintain the wildlife occurring on these lands. The private sector is not bound to maintain the wildlife and the priorities of the private sector rarely, if ever, match the needs of the wildlife. The conversion of any BLM land to private lands will not only eliminate that parcel, but will also eliminate a significant portion of the immediately adjacent area due to the subsequent activities which occur on the private lands and because of the buffer zone established by the breeding curlews.

The refusal of curlews to establish breeding territories within approximately 0.4 km of areas of heavy human use has significant implications. Curlews don't need little patches of isolated habitat, they need big expanses of short grass rangeland devoid of human disturbance. If the owners of rangeland inholdings start developing them for any purpose, curlews will be unable to use not only those inholdings, but all adjoining rangeland within a radius of at least 0.4 - 0.5 km as well (a single 1 ha conversion would ruin a whole section for the curlews). The BLM should seriously consider consolidating its ownership of the best curlew habitats and all land immediately adjacent to them (Figure V-1). Unless the BLM can maintain large expanses of short grass rangeland all other management techniques are futile.

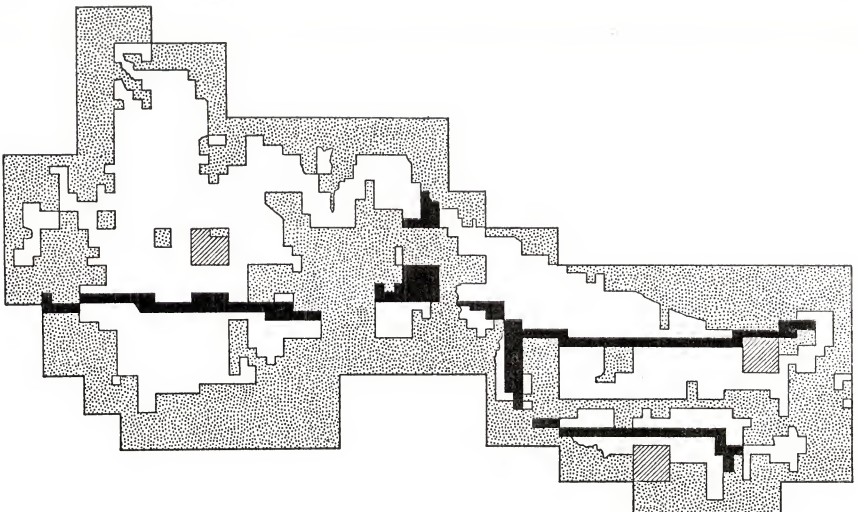


Fig. V-1: Location and extent of public, private and state land on the BCPU. Public land is white, stock driveways are black, private land is stipled and state land is cross-hatched.

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Appendix Table I-1. Precipitation at Parma, Idaho (in cm.), August, 1976 - July, 1979.

Year / Month		Total	Normal	+ From Normal	Greatest Day	Date
1976	August	3.35	1.14	+ 2.21	1.10	8/1
	September	5.03	1.19	+ 3.84	2.03	9/12
	October	0.38	2.18	- 1.80	0.18	10/25
	November	0.74	3.15	- 2.41	0.41	11/15
	December	0.66	3.33	- 2.67	0.30	12/5
1977	January	2.03	3.60	- 1.57	1.73	1/3
	February	0.53	2.54	- 2.01	0.28	2/24
	March	1.55	2.06	- 0.51	0.46	3/3
	April	0.36	2.15	- 1.80	0.36	4/1
	May	5.51	3.05	+ 2.46	1.73	5/27
	June	0.43	2.59	- 2.16	0.18	6/8
	July	0.46	0.38	+ 0.08	0.28	7/25
12 Month Totals		21.03	27.36	- 6.33	2.03	9/12/76
1977	August	1.40	1.14	+ 0.25	0.76	8/24
	September	3.30	1.19	+ 2.11	0.97	9/29
	October *	0.28	2.18	- 1.90	0.13	10/30
	November	5.26	3.15	+ 2.11	1.60	11/25
	December	4.98	3.33	+ 1.65	1.19	12/15
1978	January	9.19	3.60	+ 5.59	2.62	1/17
	February	4.24	2.54	+ 1.70	1.04	2/15
	March	2.34	2.06	+ 0.28	0.74	3/24
	April	8.53	2.15	+ 6.38	1.63	4/16
	May	0.41	3.05	- 2.64	0.18	5/11
	June	1.09	2.59	- 1.50	0.46	6/25
	July	1.07	0.38	+ 0.69	0.58	7/4
12 Month Totals		42.09	27.36	+14.73	2.62	1/17/78
1978	August	2.84	1.14	+ 1.70	2.57	8/13
	September	1.27	1.19	+ 0.08	0.66	9/6
	October	0	2.18	- 2.18	--	--
	November	1.52	3.15	- 1.63	0.94	11/29
	December	1.78	3.33	- 1.55	0.71	12/1
1979	January	4.90	3.60	+ 1.30	3.05	1/11
	February	3.20	2.54	+ 0.66	0.99	2/14
	March	2.44	2.06	+ 0.38	1.19	3/16
	April	1.83	2.15	- 0.33	0.46	4/9
	May	2.08	3.05	- 0.96	0.86	5/8
	June	0.61	2.59	- 1.98	0.41	6/18
	July	Trace	0.38	- 0.38	Trace	7/22
12 Month Totals		22.47	27.36	- 4.89	3.05	1/11/79

* No data from Parma Station; data included from Payette, Idaho for this month (October, 1977).

Appendix Table I-2. Mean daily temperatures (°C) recorded at Parma, Idaho, for months, August, 1976 - July, 1979.

Year	Month	Maxima	Minima	Mean	Normal	Departure from Normal
1976	August	27.8	9.8	18.8	21.4	-2.6
	September	25.8	6.7	16.3	16.4	-0.1
	October	19.6	- 1.4	9.1	10.2	-1.1
	November	11.5	- 5.0	3.3	3.8	-0.5
	December	3.8	-10.6	- 3.4	- 0.2	-3.2
1977	January	- 3.3	-12.6	- 7.9	- 2.2	-5.7
	February	4.4	- 6.8	- 1.2	1.7	-2.9
	March	12.2	- 3.2	4.5	5.4	-0.9
	April	22.0	2.6	12.3	10.1	-2.2
	May	18.8	4.9	11.9	14.5	+2.6
	June	31.1	12.4	21.8	18.3	+3.5
	July	32.5	11.8	22.2	22.7	-0.5
1977	August	33.1	11.9	22.6	21.4	+1.2
	September	25.7	5.8	15.8	16.4	-0.6
	October *	18.9	1.4	10.2	10.6	-0.4
	November	9.1	- 3.7	2.7	3.8	-1.1
	December	6.9	- 2.1	2.4	- 0.2	+2.6
1978	January	5.5	- 3.1	1.2	- 2.2	+3.4
	February	7.4	- 1.8	2.8	1.7	+1.1
	March	16.5	- 0.1	8.2	5.4	+2.8
	April	15.7	3.2	9.4	10.1	-0.7
	May	20.6	5.1	12.8	14.5	-1.7
	June	27.2	7.5	17.4	18.3	-0.9
	July	32.3	11.7	22.0	22.7	-0.7
	August	32.6	9.6	21.1	21.4	-0.3
	September	25.0	6.3	15.7	16.4	-0.7
1978	October	21.7	- 1.1	10.3	10.2	+0.1
	November	8.2	- 6.4	0.9	3.8	-2.9
	December	1.9	- 8.7	- 3.4	- 0.2	-3.2
1979	January	- 4.5	-16.6	-10.5	- 2.2	-8.3
	February	3.9	- 5.0	- 0.6	1.7	-2.3
	March	13.6	- 0.7	6.4	5.4	+1.0
	April	16.9	1.7	9.3	10.1	-0.8
	May	23.7	7.1	15.4	14.5	+0.9
	June	28.5	9.3	18.9	18.3	+0.6
	July	33.1	11.7	22.4	22.7	-0.3

* No data from Parma Station; data included from Payette, Idaho for this month (October, 1977).

Appendix Table I-3: Long-billed Curlews banded and color-marked on the BCPU, 1977-79.

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
1	5/8/77	Ad./F	704-80101	Al WW	WWR	
2	5/8/77	Chick	704-80102	Al RR	WWR	
3	5/8/77	Chick	704-80103	Al RR	WRR	
4	5/8/77	Chick	704-80104	Al RR	RRW	
5	5/8/77	Chick	704-80105	Al RR	WWW	
6	5/9/77	Ad./F	765-48401	Al WW	WRR	
7	5/10/77	Ad./F	765-48402	Al WW	RRR	
8	5/11/77	Ad./F	765-48403	Al WB	WWB	
9	5/11/77	Ad./M	765-48404	Al WB	WWR	
10	5/11/77	Ad./M	765-48405	Al WW	WBB	
11	5/12/77	Chick	704-80106	Al RR	RWW	
12	5/12/77	Chick	704-80107	Al RR	WRW	R
13	5/12/77	Chick	704-80108	Al RR	RWR	
14	5/12/77	Chick	704-80109	Al RR	WWB	
15	5/12/77	Ad./F	765-48406	Al WW	BBB	
16	5/13/77	Chick	704-80110	Al RR	WBB	
17	5/13/77	Chick	704-80111	Al RR	BBW	
18	5/14/77	Chick	704-80112	Al RR	BWW	R
19	5/14/77	Chick	765-48408	Al RR	BWB	
20	5/14/77	Chick	765-48407	Al RR	WBW	
21	5/14/77	Chick	704-80113	Al BB	WWR	R
22	5/14/77	Chick	704-80114	Al BB	WWW	
23	5/14/77	Chick	704-80115	Al BB	WRR	
24	5/16/77	Chick	765-48409	Al BB	RWW	
25	5/16/77	Chick	704-80116	Al BB	RRW	
26	5/16/77	Chick	765-48410	Al BB	WRW	
27	5/16/77	Chick	765-48411	Al BB	RWR	
28	5/16/77	Chick	Perished; Bands Recovered 5/17/77			
29	5/16/77	Chick	704-80118	Al BB	WBB	
30	5/16/77	Chick	704-80119	Al BB	BBW	
31	5/16/77	Chick	765-48412	Al BB	BWW	
32	5/16/77	Chick	765-48413	Al BB	WBW	
33	5/16/77	Chick	765-48414	Al BB	BWB	R
34	5/17/77	Chick	765-48415	Al RB	WWW	
35	5/17/77	Chick	704-80122	Al RB	WWR	
36	5/17/77	Chick	765-48416	Al RB	WRR	
37	5/17/77	Chick	Perished; Bands Recovered 5/20/77			
38	5/17/77	Chick	704-80120	Al RB	RWW	
39	5/17/77	Chick	704-80121	Al RB	WRW	
40	5/18/77	Chick	765-48417	Al BR	WWB	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
41	5/18/77	Chick	704-80123	Al BR	WBB	R
42	5/18/77	Chick	704-80124	Al BR	BBW	
43	5/18/77	Chick	704-80125	Al BR	BWW	
44	5/18/77	Chick	704-80126	Al BR	WBW	
45	5/18/77	Chick	765-48418	Al BR	BWB	
46	5/18/77	Chick	765-48419	Al BR	RWR	R
47	5/18/77	Chick	765-48420	Al BR	WRW	
48	5/18/77	Chick	704-80127	Al BR	WWW	I
49	5/18/77	Chick	704-80128	Al BR	RWW	R
50	5/19/77	Chick	704-80129	Al BR	WWR	
51	5/19/77	Chick	765-48442	Al BR	WRR	I
52	5/20/77	Chick	704-80131	Al BR	RRW	
53	5/20/77	Chick	704-80132	Al RB	RWR	
54	5/20/77	Chick	704-80133	Al RB	WWB	
55	5/20/77	Chick	704-80134	Al RB	WBB	
56	5/20/77	Chick	765-48421	Al RB	BBW	
57	5/20/77	Chick	765-48422	Al RB	BWW	
58	5/20/77	Chick	704-80135	Al RB	WBW	?R
59	5/22/77	Chick	704-80136	Al RB	WBW	
60	5/22/77	Chick	704-80137	Al RB	BWB	
61	5/22/77	Chick	704-80138	Al BW	WWR	
62	5/23/77	Chick	765-48423	Al WR	WRR	R
63	5/23/77	Chick	765-48424	Al WR	RRR	
64	5/23/77	Chick	704-80139	Al WR	RRW	
65	5/23/77	Chick	704-80140	Al WR	RWW	
66	5/23/77	Chick	765-48425	Al WR	WRW	R
67	5/23/77	Chick	704-80141	Al WR	RWR	R
68	5/24/77	Chick	765-48426	Al WR	WWW	R
69	5/24/77	Ad./M	765-48427	Al WW	RRW	I
70	5/24/77	Chick	704-80142	Al WR	WWB	
71	5/24/77	Chick	704-80143	Al WR	WBB	
72	5/24/77	Chick	704-80144	Al WR	BBB	I
73	5/25/77	Chick	704-80145	Al WR	WWR	
74	5/25/77	Chick	765-48428	Al WR	BBW	I
75	5/27/77	Chick	Perished; Bands Recovered 6/11/77			I
76	5/27/77	Ad./M	704-80146	Al WW	WWB	I
77	5/28/77	Chick	704-80147	Al WR	WBW	
78	5/28/77	Chick	704-80148	Al WR	BWB	I
79	5/28/77	Chick	704-80149	Al WR	BBR	R
80	5/28/77	Chick	765-48430	Al WR	BRR	I

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
81	5/28/77	Chick	765-48431	Al WR	RRB	
82	5/28/77	Chick	704-80150	Al WR	RBB	R
83	5/29/77	Chick	765-48432	Al WR	BRB	I
84	5/29/77	Chick	765-48433	Al WR	RBR	
85	5/30/77	Chick	704-80151	Al WB	WRR	
86	5/30/77	Chick	704-80152	Al WB	RRR	
87	5/30/77	Chick	765-48434	Al WB	RRW	
88	6/2/77	Chick	765-48435	Al WB	RWW	
89	* 6/5/77	Chick	765-48438	Al WB	WRW	R
90	6/8/77	Chick	Perished; Bands Recovered 6/9/79			I
91	6/9/77	Chick	765-48440	Al WB	WWW	R
92	6/16/77	Chick	765-48441	Al WB	BWW	I&R
93	6/16/77	Chick	704-80155	Al WB	WBB	I
94	6/18/77	Chick	765-48443	Al WB	BBB	I&R
95	6/18/77	Chick	704-80153	Al WB	RBB	
96	7/2/77	Chick	765-48444	Al WB	BRR	I&E
97	7/6/77	Chick	765-48445	Al WB	BBR	R
98	7/6/77	Chick	765-48446	Al WB	BWB	R
99	* 7/12/77	Chick	765-48438	Al WB	RRB	R
100	5/22/77	Chick	Perished; Bands Recovered 5/23/77			
101	4/23/78	Ad./M	765-48447	Al WW	RWW	I
102	4/24/78	Ad./F	765-48448	Al WW	RWR	I
103	4/24/78	Ad./M	765-48449	Al WW	WRW	
104	4/28/78	Ad./F	765-48450	Al WW	BBR	
105	4/28/78	Ad./F	765-48451	Al RB	RRW	
106	5/2/78	Ad./F	765-48452	Al WW	BWW	
107	5/3/78	Ad./F	765-48453	Al WW	BBW	
108	5/3/78	Ad./F	765-48454	Al WW	BRR	
109	5/4/78	Ad./F	765-48455	Al WW	RBB	
110	5/4/78	Ad./F	765-48456	Al WW	RRB	I
111	5/6/78	Chick	765-48457	Al BB	YYW	R
112	5/7/78	Chick	765-48458	Al BB	WWY	
113	5/7/78	Chick	765-48459	Al BB	WYY	
114	5/7/78	Chick	765-48460	Al BB	YWW	
115	5/7/78	Chick	765-48461	Al BB	YWY	
116	5/7/78	Chick	765-48462	Al BB	WYW	R
117	5/7/78	Chick	765-48463	Al BB	BYW	
118	5/8/78	Chick	765-48464	Al BB	WYB	
119	5/8/78	Chick	815-44801	Al RR	YYW	
120	5/8/78	Chick	815-44802	Al RR	WWY	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
121	5/8/78	Chick	815-44803	Al RR -	WYY	
122	5/8/78	Chick	765-48465	Al BB -	WBY	
123	5/8/78	Ad./M	704-80156	Al WW -	RBR	
124	5/8/78	Ad./F	815-44804	Al WW -	BRB	
125	5/8/78	Ad./M	704-80157	Al WW -	BWB	
126	5/9/78	Chick	815-44805	Al RR -	YWW	
127	5/9/78	Chick	815-44806	Al RR -	YWY	
128	5/9/78	Chick	815-44807	Al RR -	WYW	
129	5/9/78	Chick	815-44808	Al RR -	BYW	
130	5/9/78	Chick	815-44809	Al RR -	WYB	
131	5/9/78	Chick	815-44810	Al RR -	WBY	
132	5/10/78	Chick	815-44811	Al RR -	YWB	
133	5/10/78	Chick	815-44812	Al RR -	YBW	
134	5/10/78	Chick	765-48466	Al BB -	YWB	
135	5/10/78	Chick	765-48469	Al BB -	YBW	
136	5/10/78	Chick	765-48470	Al BB -	BWY	
137	5/10/78	Chick	765-48471	Al BB -	RYW	
138	5/10/78	Chick	765-48472	Al BB -	WRY	
139	5/11/78	Chick	Perished; Bands Recovered 6/25/78			
140	5/11/78	Chick	765-48473	Al BB -	WRY	
141	5/11/78	Chick	Perished; Bands Recovered 5/12/78			
142	5/12/78	Chick	815-44814	Al RR -	RYW	R
143	5/12/78	Chick	815-44815	Al RR -	WYR	
144	5/12/78	Chick	815-44816	Al RR -	WRY	
145	5/12/78	Chick	815-44817	Al RR -	YWR	
146	5/12/78	Chick	815-44818	Al RR -	YRW	
147	5/12/78	Chick	815-44819	Al RR -	RWY	
148	5/12/78	Chick	815-44820	Al RR -	BRW	R
149	5/12/78	Chick	815-44821	Al RR -	BWR	
150	5/12/78	Chick	815-44822	Al RR -	WBR	I
151	5/12/78	Ad./F	815-44823	Al WW -	RWB	
152	5/12/78	Chick	765-48474	Al BB -	YWR	
153	5/12/78	Chick	765-48475	Al BB -	YRW	
154	5/12/78	Chick	765-48476	Al BB -	RWY	
155	5/13/78	Chick	815-44824	Al RR -	WRB	
156	5/13/78	Chick	815-44825	Al RR -	RWB	
157	5/15/78	Chick (F)	Perished; Bands Recovered 6/24/78			I
158	5/15/78	Chick	815-44827	Al YB -	WWW	
159	5/15/78	Chick	815-44828	Al YB -	WWR	
160	5/15/78	Chick	765-48477	Al YY -	WYB	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
161	5/23/78	Chick	765-48481	Al YY	RWW	*
162	5/19/78	Chick	Perished; Bands Recovered 6/22/78			I
163	5/19/78	Chick	Perished; Bands Recovered 6/14/78			I
164	5/19/78	Ad./F	815-44831	Al WW	WBW	
165	5/20/78	Ad./F	Emaciated with Broken Mandible - Collected			
166	5/26/78	Chick	815-44832	Al YB	RWR	
167	5/26/78	Chick	Perished; Bands Recovered 6/26/78			
168	5/26/78	Chick	815-44834	Al YB	RWB	
169	5/26/78	Chick	815-44835	Al YB	WBR	
170	5/26/78	Chick	815-44836	Al YB	WRB	
171	5/27/78	Ad./F	815-44837	Al WW	WBR	
172	5/27/78	Chick	815-44838	Al YB	RBW	
173	5/28/78	Chick	Perished; Bands Recovered 6/4/78			
174	5/28/78	Chick	815-44840	Al YB	BWR	
175	5/31/78	Chick	815-44841	Al BY	WRW	
176	6/4/78	Chick	815-44842	Al YB	RWW	
177	6/12/78	Chick	815-44843	Al YB	WWB	
178	6/14/78	Chick	815-44844	Al YB	WBB	R
179	6/14/78	Chick (M)	Perished; Bands Recovered 6/16/78			I
180	6/16/78	Chick	Perished; Bands Recovered 6/19/78			I
181	6/16/78	Chick	Perished; Bands Recovered 6/18/78			I
182	6/18/78	Chick	815-44848	Al YB	BBW	
183	6/18/78	Chick	815-44849	Al YB	BWW	
184	6/18/78	Chick	Perished; Bands Recovered 6/20/78			I
185	6/18/78	Chick	815-44851	Al BY	RWB	
186	6/18/78	Chick	815-44852	-		
187	6/22/78	Chick	Perished; Bands Recovered 7/9/78			I
188	6/25/78	Chick (F)	Perished; Bands Recovered 6/30/78			I
189	6/25/78	Chick	815-44855	Al YY	RWW	R*
190	6/25/78	Chick	765-48482	Al YY	RRW	R
191	6/25/78	Chick	765-48483	Al YY	RWR	R
192	6/25/78	Chick	815-44856	Al YY	WRW	R
193	6/29/78	Chick	815-44857	Al BY	BRW	R
194	6/29/78	Chick (M)	Perished; Bands Recovered 7/11/78			I
195	6/29/78	Chick	Perished; Bands Recovered 7/9/78			I
196	7/4/78	Chick (M)	Perished; Bands Recovered 7/7/78			I
197	7/4/78	Ad./F	Left Wing Severed At Carpal Joint - Collected			
198	5/20/78	Chick	765-48478	Al YY	WWW	
199	5/20/78	Chick	765-48479	Al YY	WWR	
200	5/20/78	Chick	765-48480	Al YY	WRR	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
201	5/1/79	Ad./F	704-80158	Al WW -	BRW	
202	5/3/79	Ad./F	815-44860	Al WW -	BWR	I
203	5/3/79	Ad./F	815-44861	Al WW -	RBW	
204	5/3/79	Ad./F	704-80159	WRB -	Al WW	
205	5/4/79	Ad./F	815-44862	Al WW -	WRB	I
206	5/4/79	Ad./F(?)	704-80160	RBW -	Al WW	
207	5/4/79	Ad./F	815-44863	BWR -	Al WW	I
208	5/5/79	Ad./F	815-44864	BRW -	Al WW	
209	5/10/79	Ad./F	815-44865	RWB -	Al WW	
210	5/12/79	Chick	Perished; Bands Recovered 5/14/79			I
211	5/13/79	Ad./M	704-80161	Al BB -	WRB	I
212	5/14/79	Ad./M	704-80162	Al BB -	BWR	
213	5/14/79	Chick	815-44867	-		I
214	5/15/79	Chick	815-44868	Al YB -	YRW	
215	5/15/79	Chick	815-44869	Al YB -	RWY	
216	5/15/79	Chick	815-44870	Al YB -	YYW	
217	5/15/79	Chick	815-44871	Al YB -	WWY	
218	5/15/79	Chick	815-44872	Al YB -	YWW	
219	5/15/79	Chick	815-44866	Al YB -	YWY	
220	5/15/79	Chick	815-44873	-		I
221	5/15/79	Chick	815-44875	Al YB -	WYY	
222	5/15/79	Chick	815-44876	Al YB -	YWW	
223	5/16/79	Chick	-	-		I
224	5/16/79	Chick	815-44877	Al YB -	WBY	I
225	5/16/79	Chick	815-44878	Al YB -	WYB	
226	5/16/79	Chick	815-44879	Al YB -	BYW	
227	5/16/79	Chick	815-44880	Al YB -	YWB	
228	5/16/79	Chick	815-44881	Al YB -	BWY	
229	5/16/79	Chick	815-44882	Al YB -	YBW	
230	5/16/79	Chick	765-48485	Al YY -	RWB	
231	5/16/79	Chick	765-48486	Al YY -	RBW	
232	5/16/79	Chick	765-44487	Al YY -	WBR	
233	5/17/79	Ad./M	704-80163	Al BB -	WBR	
234	5/17/79	Ad./F	815-44883	Al BB -	RBW	
235	5/17/79	Chick	815-44884	Al YB -	RYW	I
236	5/17/79	Chick	815-44885	Al YB -	WYR	
237	5/18/79	Chick	815-44887	Al YB -	RYW	
238	5/18/79	Chick	815-44886	Al YB -	YWR	
239	5/18/79	Chick	Perished; Bands Recovered 5/19/79			
240	5/21/79	Chick	815-44888	Al BY -	WWR	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
241	5/21/79	Chick	815-44889	Al BY -	WRR	
242	5/21/79	Chick	765-48492	Al YY -	WRB	
243	5/22/79	Chick	815-44891	Al BY -	WYW	I
244	5/22/79	Chick	Perished; Bands Recovered 5/23/79			I
245	5/22/79	Chick	815-44893	Al BY -	YWY	I
246	5/22/79	Chick	Perished; Bands Recovered 5/23/79			I
247	5/22/79	Chick	765-48488	Al YY -	BBW	
248	5/22/79	Chick	815-44890	Al BY -	RWW	
249	5/23/79	Chick	815-44895	-		I
250	5/24/79	Ad./M	704-80164	Al BB -	RWB	I
251	5/25/79	Chick	765-48490	Al YY -	BRW	
252	5/25/79	Chick	765-48489	Al YY -	BWW	
253	5/25/79	Chick	765-48491	Al YY -	BWR	
254	5/25/79	Chick	815-44894	Al YB -	WRY	
255	5/25/79	Chick	815-44892	Al BY -	RRW	
256	5/25/79	Chick	815-44896	-		I
257	5/25/79	Chick	815-44897	Al BY -	RWR	I
258	5/26/79	Chick	815-44898	-		I
259	5/26/79	Chick	Perished; Bands Recovered 6/1/79			I
260	5/26/79	Chick	815-44900	-		I
261	5/27/79	Chick	815-89602	-		I
262	5/27/79	Ad./F	815-89601	Al BB -	BRW	I
263	5/28/79	Chick	765-48493	Al YY -	WBB	
264	5/28/79	Chick	765-48494	Al YY -	WWB	
265	5/28/79	Chick	765-48495	Al YY -	WBW	
266	5/28/79	Chick	765-48496	Al YY -	BWB	
267	5/29/79	Chick	Perished; Bands Recovered 5/30/79			
268	5/29/79	Chick	815-89603	Al BY -	WWB	
269	5/29/79	Chick	815-89604	Al BY -	WBB	
270	5/29/79	Ad./F	Perished; Bands Recovered 7/29/79			I
271	5/30/79	Chick	Perished; Bands Recovered 5/30/79			
272	5/30/79	Chick	815-89626	Al BY -	WBW	
273	5/30/79	Chick	815-89627	Al BY -	BWB	
274	5/30/79	Chick	815-89628	Al BY -	YRW	
275	5/30/79	Chick	815-89629	Al BY -	RWY	
276	5/30/79	Chick	815-89630	Al BY -	YYW	
277	6/2/79	Chick	815-44899	Al BY -	WWY	
278	6/2/79	Chick	815-89631	Al BY -	WYY	
279	6/4/79	Ad./M	704-80165	RWR -	Al WR	I
280	6/5/79	Chick	765-48497	Al YY -	YRW	

Appendix Table I-3: Continued

No.	Date Captured	Age/Sex (At Capture)	U.S.F.W.S. Al Code No.	Color Combination Left Leg	Right Leg	Comments
281	6/7/79	Chick	Perished; Bands Recovered 6/8/79			I
282	6/7/79	Chick	Perished; Bands Recovered 6/8/79			I
283	6/7/79	Chick	Perished; Bands Recovered 6/11/79			I
284	6/8/79	Chick	815-89634	Al BY -	YWW	
285	6/9/79	Chick	Perished; Bands Recovered 6/10/79			I
286	6/9/79	Chick	Perished; Bands Recovered 6/10/79			I
287	6/9/79	Chick	Perished; Bands Recovered 6/25/79			I
288	6/9/79	Chick	Perished; Bands Recovered 6/18/79			I
289	6/9/79	Chick	815-89638	-		I
290	6/9/79	Chick	Perished; Bands Recovered 6/10/79			I
291	6/11/79	Chick	Perished; Bands Recovered 6/12/79			I
292	6/12/79	Chick	Perished; Bands Recovered 6/22/79			I
293	6/13/79	Chick	Perished; Bands Recovered 6/14/79			
294	6/15/79	Chick	815-89642	Al WR -	BYR	
295	6/15/79	Chick	815-89643	Al WR -	RBY	
296	6/12/79	Chick	765-48498	Al YY -	RWY	
297	6/18/79	Chick	Perished; Bands Recovered 6/23/79			I
298	6/18/79	Chick	Perished; Bands Recovered 6/23/79			I
299	6/19/79	Chick	815-89646	Al BY -	WYB	I
300	6/22/79	Chick	815-89606	Al YY -	YYW	
301	6/24/79	Chick	815-89647	Al YY -	YWR	I
302	6/26/79	Chick	815-89648	Al BY -	BYW	
303	6/26/79	Chick	815-89649	Al BY -	WYR	I
304	6/27/79	Chick	815-89650	Al BY -	YWB	
305	6/26/79	Chick	815-89651	Al BY -	BWY	I
306	6/27/79	Chick	815-89652	Al BY -	RYW	I
307	7/4/79	Chick	815-89654	Al BY -	WRY	I
308	7/7/79	Chick	815-89655	Al BY -	YWR	I
309	6/28/79	Chick	815-89653	Al BY -	YBW	
310	6/30/79	Chick	765-48499	Al YY -	WWY	
311	6/16/79	Chick	765-48500	Al YY -	WYY	
312	6/30/79	Chick	815-89607	Al YY -	YWW	R
313	7/4/79	Chick	815-89608	Al YY -	YWY	
314	7/5/79	Chick	815-89610	Al YY -	WYW	

I = Instrumented
R = Resighted in Post-fledging Flock at End of Season
E = Tarter Emetic Administered

Appendix T II-1. Timing of Long-billed Curlew breeding events on the BCPU, 1977-79.

Year		Arrival	Pre-laying (variable)	Laying (5-7 days)	Incubation (28 days)	Hatching	Brood Rearing (44 days)	Adults Depart	Flocking
1977	Range	3/21-?		4/1-5/14	4-7/6/10	5/5-6/11	5/5-7/25		7/6-8/13
	Peak Period[1]	3/24-3/30	3/31-4/12	4/13-4/19	4/19-5/16	5/17	5/17-6/30	6/18-6/23	7/15-7/27
1978	Range	3/19-?		4/1-5/25	4/7-6/21	5/5-6/22	5/5-8/5[2]		7/1-8/8
	Peak Period	3/23-3/29	3/30-4/8	4/9-4/15	4/15-5/12	5/13	5/13-6/26	6/12-6/17	7/15-7/30
1979	Range	3/20-?		4/5-5/24	4/11-6/20	5/9-6/21	5/9-8/4[2]		7/10-8/9
	Peak Period	3/25-3/31	4/1-4/18	4/19-4/25	4/25-5/22	5/23	5/23-7/6	6/25-6/30	7/20-7/31
1977-1979	Range	3/19-?		4/1-5/25	4/7-6/21	5/5-6/22	5/5-8/5	6/12-6/30	7/1-8/13
	Peak Period	3/23-3/31	3/31-4/13	4/14-4/20	4/20-5/17	5/18	5/18-7/1	6/18-6/23	7/17-7/29

[1] Peak periods determined from median hatching dates for each year, and from general field observations of arriving and flocking birds.

[2] These are not observed dates, rather projected from latest hatching nests - chicks from both were not known to survive this long.

Appendix Table II-2. Mineral contents of one Long-billed Curlew egg. Energy content was 5.67 Kcal/g, and the egg was 21.4% ash. (All calculations based on dry weight including shell).[1]

	Total amount (g)	Relative amount (ppm)
Calcium (Ca)	4.7660	7.20×10^4
Total Nitrogen (N)	4.1083	6.21×10^4
Sodium (Na)	0.3853	5.82×10^3
Potassium (K)	0.2833	4.28×10^3
Phosphate (PO_4)	0.1588	2.40×10^3
Arsenic (As)	0.0616	9.30×10^2
Magnesium (Mg)	0.0606	9.16×10^2
Iron (Fe)	9.8×10^{-3}	1.49×10^2
Zinc (Zn)	9.0×10^{-3}	1.36×10^2
Lead (Pb)	1.7×10^{-3}	26.0
Copper (Cu)	1.1×10^{-3}	17.0
Manganese (Mn)	0.5×10^{-3}	7.10
Cadmium (Cd)	0.1×10^{-3}	1.80
Aluminum (Al)	0	0

[1] Fresh weight of egg on day after laying was 68.4 g.

Appendix Table II-3. Summary of data on 62 radio-marked Curlew chicks on the BCPU, 1977-79.

	Chick No.	No. Tracking Days	No. of Locations	Age when Instrumented (days)	Age when Lost, Died, or Radio Removed	Fate
1977	48	31	23	35	65	Fledged with radio; last fix 7/9/77.
	51	0	1	29		Fledged with faulty radio.
	72	42	29	17	58	Fledged with radio; last fix 7/4/77.
	74	2	2	10	11	Chick shed radio; fate unknown
	75	11	10	10	20	Killed by weasel (?) approx. 6/6/77.
	78	12	12	1	12	Signal lost; fate unknown.
	80	30	27	23	52	Fledged with radio; last fix 7/19/77.
	83	29	26	11	39	Radio removed at fledging.
	90	0	1	6	6	Cause of death unknown.
	92	3	3	5	7	Chick shed radio; sighted post-fledging.
	93	30	28	5	34	Fledged with radio; last fix 7/15/77.
	94	5	4	20	24	Radio removed; sighted post-fledging.
	96	3	3	34	36	Radio removed.
	N=13	198	169	$\bar{x}$ = 15.8 days		
1978	150	12	7	5	16	Signal lost; fate unknown.
	157	43	19	5	46	Killed by raptor just after fledging.
	162	34	15	11	44	Killed by raptor.
	163	26	10	11	36	Died; aspergillosis in lungs.
	179	3	2	18	20	Killed by Ferruginous Hawk.
	180	4	3	10	13	Killed by owl.
	181	2	2	10	11	Killed by Burrowing Owl.
	184	2	2	6	7	Killed by raptor.

Appendix Table II-3. Continued

	Chick No.	No. Tracking Days	No. of Locations	Age when Instrumented (days)	Age when Lost, Died, or Radio Removed	Fate
1978 Cont.	187	16	16	39	54	Killed by raptor after fledging.
	188	6	4	20	25	Died; aspergillosis in lungs.
	194	12	12	28	39	Killed by raptor.
	195	10	9	7	16	Killed by raptor.
	196	3	2	12	14	Killed by raptor.
	N=13	173	103	$\bar{x}$ = 14 days		
1979	210	1	2	1	2-3	Found dead and eaten by magpie?
	213	7	5	0	6	Chick shed radio; fate unknown
	220	8	7	0	7	Chick shed radio; fate unknown
	223	1	1	1	2	Chick shed radio; fate unknown
	224	14	11	30	43	Radio removed during fledging.
	235	4	4	1	4	Chick shed radio; fate unknown
	243	76	64	0	-	Chick fledged with radio; last fix 8/4/79.
	244	0	1	0	0	Chick died near nest; cause unknown.
	245	13	14	2	14	Chick shed radio; fate unknown
	249	3	3	2	5	Chick shed radio; fate unknown
	256	0	1	2	2	Chick shed radio; fate unknown
	257	43	29	32	-	Chick fledged with radio; last fix 8/4/79.
	258	4	4	2	5	Signal lost; fate unknown.
	259	6	5	0	5	Cause of death unknown.
	260	4	4	0	3	Chick shed radio; fate unknown
	261	3	3	0	3	Chick shed radio; fate unknown
	281	1	1	0	1	Chick died near nest; cause unknown.
	282	0	1	0	0	Chick died near nest.

Appendix Table II-3. Continued

	Chick No.	No. Tracking Days	No. of Locations	Age when Instrumented (days)	Age when Lost, Died, or Radio Removed	Fate
1979	283	4	4	1	4	
Cont.	285	0	1	0	0	Chick starved to death??
	286	0	1	0	0	Cause of death unknown.
	287	17	15	0	16	Cause of death unknown.
	288	10	8	0	9	Killed by weasel?
	289	2	3	1	2	Killed by mammalian predator?
	290	0	1	1	1	Chick shed radio; fate unknown
	291	0	1	8	8	Cause of death unknown.
	292	4	4	3	6	Cause of death unknown.
	297	5	5	0	4	Killed by Marsh Hawk.
	298	4	4	1	4	Died of heat stress?
	299	8	8	25	32	Died of heat stress?
	301	3	3	15	17	Radio removed, fate unkown.
	303	41	33	13	-	Chick shed radio; sighted post-fledging.
	305	2	3	21	22	Fledged with radio; last fix 8/4/79.
	306	34	32	12	-	Radio removed; fate unknown.
	307	16	16	21	-	Fledged with radio; last fix 7/31/79.
	308	3	3	22	24	Chick fledged with radio; last fix 7/20/79.
	N=36	341	305	$\bar{x}$ = 6.0 days		Signal lost, fate unknown.
TOTALS	62	712	577	$\bar{x}$ = 11.9 days		

Appendix Table II-4. Long-billed Curlew nest failures, 1977-79.

Nest No.	Study Area[1]	Date Found	Loss Attributed To	Comments
1977				
4	SH	5/14/77	Canid	
5	SH	5/14/77	Badger	
7	SH	5/18/77	Badger	
12	SH	4/27/77	Badger	
14	SH	5/14/77	Badger	
15	SH	4/30/77	Canid	
16	SH	5/8/77	Badger	
19	SH	5/6/77	Badger	
20	SH	5/7/77	Canid	
23	SH	5/13/77	Badger	
24	SH	5/7/77	Avian	
30	LFO	5/29/77	Avian*	Probable human disturbance forced initial abandonment.
1978				
33	LFO	4/24/78	Sheep	Eggs broken and kicked out of nest cup. Abandoned.
34	SH	4/30/78	Canid	
36	LFO	4/29/78	Canid	
37	LFO	5/10/78	Canid	
39	LFO	4/24/78	Sheep	Egg broken in cup and nest abandoned.
43	LFO	4/28/78	Avian*	Probable sheep disturbance forced initial abandonment.
44	LFO	5/8/78	Badger	
46	LFO	4/21/78	Sheep	Abandoned during incubation.
47	LFO	5/3/78	Canid	
49	LFO	5/21/78	Mammal	Difficult to specify predator; possibly canid or weasel?
50	LFO	5/8/78	Canid	
57	LFO	5/12/78	Canid	
59	SH	5/13/78	Avian*	Probable human disturbance forced initial abandonment.
60	SH	5/29/78	Badger	
63	LFO	5/8/78	Badger	
68	LFO	5/29/78	Canid	
1979				
76	SH	4/23/79	Badger	
77	SH	5/21/79	Badger	
81	LFO	4/29/79	Mammal	Difficult to specify predator; possibly canid or weasel?
82	SH	5/11/79	Badger	
85	LFO	5/10/79	Canid	

Appendix Table II-4. Continued

Nest No.	Study Area[1]	Date Found	Loss Attributed To	Comments
1979				
86	SH	5/2/79	Canid	
87	LFO	4/27/79	Canid	
88	LFO	4/29/79	Avian*	Abandoned during incubation-possible human disturbance.
89	LFO	5/13/79	Canid	
99	ND	5/31/79	Canid	All eggs addled and overdue to hatch.
100	SD	5/13/79	Canid	
101	SD	5/16/79	Avian	
103	LFO	5/28/79	Canid	
104	LFO	5/9/79	Canid	
105	LFO	5/20/79	Avian*	Probable human disturbance forced initial abandonment.
107	LFO	5/10/79	Sheep	Sheep herder's camp forced abandonment.
108	WB	6/3/79	Heat?	Pipping eggs overheated; human disturbance.
109	ML	5/16/79	Cattle	One egg broken; nest abandoned.
110	JEN	5/12/79	Canid	
114	LFO	5/19/79	Mammal	Difficult to specify predator; possibly canid or weasel?
116	WB	5/28/79	Avian*	Probable human disturbance forced initial abandonment.
118	SD	6/4/79	Abandoned	Investigator stepped on eggs, nest abandoned.

[1] Key to study areas: SH = Sand Hollow; LFO = Little Freezeout; ND = North Dewey; SD = South Dewey; WB = White Bird Hill; ML = Mud Lake; and JEN = Jennes.

* Indicates avian predator (magpie) considered secondary cause of nest loss; see comments.

Appendix Table III-1. Vegetation heights (decimeters) on each of the 30 vegetation types.

1977

	Brood-Rearing		
Type	$\bar{x}$	SD	Rank
1	0.5	1.8	2
2	1.1	1.1	10
3	1.5	1.4	16
4	1.5	1.0	14
5	1.8	1.9	23
6	1.1	1.6	11
7	1.0	1.8	9
8	1.5	1.2	15
9	1.2	1.5	13
10	1.7	1.3	17
11	1.8	1.8	22
12	0.5	1.1	1
13	1.9	1.4	25
14	0.8	1.1	5
15	0.6	1.1	3
16	1.8	1.4	20
17	2.1	1.2	28
18	2.0	1.7	26
19	1.7	1.6	18
20	1.8	1.5	21
21	0.9	1.2	7
22	1.0	1.6	8
23	1.8	1.1	19
24	1.2	1.4	12
25	2.1	1.0	27
26	1.9	1.0	24
27	0.8	1.2	6
28	0.7	1.6	4
29	3.1	1.8	29
30	4.2	1.5	30

Appendix Table III-1. Continued 1978.

Type	Pre-Laying			Laying			Incubation			Brood-Rearing		
	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank
1	0.5	1.0	2	0.9	1.3	2	1.5	1.1	3	2.8	1.6	16
2	1.4	1.3	15	1.5	1.7	10	2.1	1.7	13	2.4	1.9	4
3	1.5	1.1	16	1.9	1.7	18	2.4	1.8	18	2.8	1.4	14
4	1.4	1.2	17	1.9	1.1	14	2.8	1.0	23	3.1	0.9	22
5	1.8	1.0	23	2.4	1.6	28	2.9	1.3	27	3.2	0.9	25
6	1.3	1.9	12	2.1	1.4	24	3.0	1.5	28	3.7	1.6	12
7	0.9	1.7	8	1.0	1.5	6	1.6	1.7	5	2.9	3.1	21
8	1.4	1.1	13	1.8	1.2	12	1.9	2.1	9	2.5	1.4	5
9	1.1	1.5	10	1.9	1.2	15	1.9	2.5	11	3.4	1.6	27
10	1.2	1.8	11	2.0	1.3	20	2.4	1.9	19	3.1	1.9	24
11	1.7	1.5	21	2.1	1.4	25	2.5	1.8	21	3.1	1.6	23
12	0.3	1.2	1	0.8	1.5	1	1.1	1.4	1	2.8	1.0	13
13	1.8	1.1	24	1.9	1.5	17	2.4	1.6	17	2.9	1.1	17
14	0.7	1.1	5	1.0	1.0	5	1.9	1.4	6	2.5	1.9	8
15	0.5	1.5	4	0.9	1.8	4	1.6	1.4	4	2.0	1.9	1
16	1.4	1.5	16	1.8	0.9	11	1.9	1.7	7	2.4	1.1	3
17	1.5	1.9	18	2.0	1.5	22	2.8	1.6	25	3.8	1.8	28
18	1.8	1.1	25	2.1	1.9	26	2.6	1.3	22	2.9	1.5	18
19	1.7	1.5	22	2.0	1.4	21	1.9	2.4	10	2.5	1.6	7
20	1.9	1.3	28	2.0	1.9	23	2.4	1.5	16	2.9	1.8	20
21	0.9	1.5	7	1.4	1.6	8	2.1	1.9	14	2.5	1.5	6
22	1.1	1.6	9	1.5	1.5	9	2.0	1.4	12	2.6	1.7	10
23	1.6	1.1	19	1.9	1.4	16	2.3	1.2	15	2.7	1.1	11
24	1.8	1.2	26	2.2	1.9	27	3.9	1.1	26	2.9	1.6	19
25	1.9	1.2	27	1.8	2.1	13	2.8	1.6	24	3.2	1.8	26
26	1.7	1.1	20	2.0	1.2	19	2.5	1.0	20	2.8	1.5	15
27	0.9	1.4	6	1.1	1.6	7	1.9	2.0	8	2.5	2.0	9
28	0.5	1.1	3	0.9	1.5	3	1.4	1.7	2	2.1	2.4	2
29	2.5	1.6	29	3.2	0.9	30	3.7	0.9	30	4.1	1.6	29
30	2.9	1.5	30	2.9	1.8	29	3.5	2.2	29	4.2	1.5	30

Appendix Table III-1. Continued 1979.

	Pre-Laying			Laying			Incubation			Brood-Rearing		
Type	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank
1	1.1	1.4	1	0.7	1.5	1	1.9	1.2	10	2.4	1.2	8
2	1.7	1.8	16	1.2	1.5	11	1.9	1.9	14	2.5	1.4	14
3	1.6	1.0	13	1.9	1.4	26	1.8	2.4	8	2.2	1.6	6
4	1.5	1.4	11	1.6	1.5	20	2.1	1.4	18	2.8	1.7	21
5	1.9	1.5	27	1.2	1.7	13	1.5	1.6	2	2.9	1.2	23
6	1.6	1.8	15	1.0	1.9	10	1.9	2.0	15	2.7	1.7	16
7	1.4	1.2	6	1.5	1.3	17	1.9	1.8	13	1.9	1.1	3
8	1.8	1.3	20	1.2	1.9	14	2.1	1.6	19	2.4	2.0	11
9	1.5	0.8	9	0.9	1.6	5	1.8	1.9	7	2.4	1.6	9
10	1.6	1.3	14	1.2	1.5	12	2.4	1.2	24	2.9	1.6	24
11	1.8	1.1	18	1.5	1.3	18	2.1	1.6	20	2.8	1.4	19
12	1.2	1.4	3	0.8	1.6	2	1.8	1.4	4	2.4	1.8	10
13	1.5	1.9	12	1.4	1.8	15	2.5	1.6	27	2.8	1.2	17
14	1.3	1.1	4	0.9	1.5	4	1.2	1.6	1	2.5	1.1	12
15	1.1	1.5	2	0.8	1.9	3	1.9	1.2	11	2.5	1.4	13
16	1.8	1.8	25	1.7	1.5	23	1.8	1.6	6	2.8	1.4	20
17	1.8	1.4	21	1.7	1.2	22	6.4	1.2	25	3.0	1.5	25
18	1.9	1.1	26	1.0	1.8	9	2.5	1.3	26	1.6	1.1	1
19	2.0	1.0	28	1.9	1.7	27	1.9	1.5	12	3.4	1.0	26
20	1.8	1.6	23	2.2	1.9	28	2.8	1.6	28	3.4	1.8	27
21	1.8	1.2	19	1.0	1.3	6	1.6	1.4	3	1.8	2.5	2
22	1.4	1.9	8	1.0	1.3	7	2.0	1.4	17	2.0	1.5	4
23	1.8	1.0	17	1.5	1.9	19	2.4	1.0	23	3.6	1.2	28
24	1.8	1.6	22	1.4	1.9	16	2.2	1.4	22	2.7	1.1	15
25	1.4	1.5	7	1.8	1.4	25	1.9	2.8	16	2.9	1.0	22
26	1.8	1.7	24	1.7	1.1	21	2.1	1.6	21	2.8	1.3	18
27	1.5	1.2	10	1.7	1.3	24	1.8	1.5	5	2.3	1.9	7
28	1.3	1.4	5	1.0	1.5	8	1.9	1.1	9	2.1	1.7	5
29	3.1	1.5	29	3.4	1.7	30	3.2	1.6	29	4.1	1.1	30
30	3.8	1.2	30	3.2	1.1	29	4.0	0.8	30	4.0	1.5	29

Appendix Table III-2. Percent vertical cover on the three 1978 fall burns during the 1979 curlew breeding season.

Burn	Stage of Breeding	Percent vertical cover at different distances (m)				
		5	10	15	20	25
Lower Homestead						
	P	5.2	6.8	5.9	10.3	11.5
	L	9.8	19.5	31.7	42.5	60.9
	I	25.8	60.1	86.7	90.0	90.0
	B	69.0	79.3	86.7	96.7	96.7
Upper Homestead						
	P	6.4	8.4	9.2	11.9	16.5
	L	15.8	25.9	41.5	59.6	50.8
	I	31.4	55.2	90.0	90.0	96.7
	B	54.5	67.8	72.2	89.3	90.0
Little Freezeout						
	P	4.8	5.5	10.9	14.5	20.2
	L	12.2	18.4	21.5	30.7	60.2
	I	15.9	29.4	51.2	60.5	76.7
	B	23.6	55.4	66.7	91.7	90.0

Appendix Table IV-1. Tallies of male Long-billed Curlews seen along survey route during pre-laying through incubation according to date and census block. Four surveys per year were selected on the basis of consistent total counts and are grouped within dashed lines.

Date	No. ♂♂ seen per census block: HMST	HIGH	SNDH	NDEW	SDEW	LFZO	WTBD	MDLK	NOAG	SOAG	Totals Per Survey
1977											
19 Apr	6	3	7			13					29
11 Apr	21	4	8			18					51
25 Apr	7	4	9			12					32
3 May	12	4	12			22					50
9 May	5	11	8			11					35
Σa =	45	23	37			63					168
$\bar{x}$ =	11.3	5.75	9.25			15.8					42.0
SD =	7.14	3.50	1.89			5.19					9.90

Appendix Table IV-1. Continued.

Date	No. ♂♂ seen per census block: HMST	HIGH	SNDH	NDEW	SDEW	LFZO	WTBD	MDLK	NOAG	SOAG	Totals Per Survey
1978											
6 Apr	21	7	14	13	7	25	13	19	0	0	119
8 Apr	19	5	18	26	10	20	13	24	0	0	135
11 Apr	44	14	29	13	8	20	21	38	0	0	187
15 Apr	19	7	25	12	2	35	6	20	0	0	126
18 Apr	22	7	24	23	19	38	11	13	0	0	157
22 Apr	28	7	25	22	14	33	11	24	0	0	164
25 Apr	25	18	19	27	14	30	17	19	0	0	169
29 Apr	25	8	32	22	12	41	15	16	0	0	171
Σ^a =	100	40	100	94	59	142	54	72	0	0	661
$\bar{x}$ =	25.0	10.0	25.0	23.5	14.8	35.5	13.5	18.0	-	-	165.3
SD =	2.45	5.35	5.35	2.38	2.99	4.93	3.00	4.69	-	-	6.24

Appendix Table IV-1. Continued.

Date	No. ♂♂ seen per census block: HMST	HIGH	SNDH	NDEW	SDEW	LFZO	WTBD	MDLK	NOAG	SOAG	Totals Per Survey
1979											
25 Apr	40	14	23	16	8	22	20	15	0	0	138
3 Apr	13	10	19	6	28	40	19	18	0	0	153
13 Apr	38	9	24	8	8	29	28	25	0	0	169
20 Apr	30	11	17	9	10	23	33	27	0	0	160
3 May	30	8	27	7	29	18	25	17	0	0	161
Σ^a =	111	38	87	30	75	110	105	87	0	0	643
$\bar{x}$ =	27.8	9.5	21.8	7.5	18.8	27.5	26.3	21.8	-	-	160.8
SD =	10.5	1.29	4.57	1.29	11.3	9.47	5.85	4.99	-	-	6.55

Appendix Table IV-2. Mean vegetation height on each "level of use" area on the BCPU for each period of the breeding seasons: 1977-79.

	1977	1978				1979			
Kind	B	P	L	I	B	P	L	I	B
A	0.26	0.36	0.66	0.90	3.00	1.52	0.88	1.14	2.38
B	0.47	0.33	0.58	0.91	2.53	1.53	1.16	1.27	2.45
C	0.47	0.30	0.88	0.95	3.00	1.36	1.11	1.50	2.17
D	0.53	0.82	0.99	1.67	2.20	1.56	1.32	1.48	2.73
E	0.83	0.88	1.31	2.21	3.40	1.89	1.34	1.78	2.68
F	1.04	0.90	1.35	2.79	3.30	1.86	1.67	1.53	2.96
G	1.39	1.22	1.57	2.52	2.84	2.20	1.43	1.54	2.78
H	1.83	2.01	2.34	3.15	2.94	2.20	1.70	1.82	3.39

Appendix Table IV-3. Mean vertical coverage values for each "level of use" area on the BCPU taken from 5 distances.

Brood-rearing 1977					
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	6.7	10.8	14.2	15.8	19.2
B	6.2	10.3	14.2	17.4	23.2
C	17.5	39.2	64.9	80.0	85.0
D	15.7	46.5	54.2	73.5	92.5
E	26.5	49.8	72.3	93.3	97.5
F	24.5	35.1	44.2	64.2	75.0
G	28.3	64.7	84.4	87.8	90.0
H	42.4	62.1	88.0	88.0	93.8

Appendix Table IV-3. Continued.

	Pre-laying 1978				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	9.2	11.5	16.4	23.3	30.3
B	6.1	13.2	17.9	23.9	28.1
C	18.3	34.0	53.5	68.3	68.3
D	18.1	42.6	57.7	71.8	80.0
E	25.1	40.1	58.9	70.9	75.0
F	23.5	50.0	58.0	64.8	82.8
G	28.1	49.7	71.1	83.3	100.0
H	31.8	49.0	63.4	76.9	88.3

Appendix Table IV-3. Continued.

	Laying 1978				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	14.2	21.7	50.8	53.3	66.7
B	17.0	26.8	44.5	53.3	59.8
C	26.5	70.4	76.7	83.3	86.7
D	28.6	56.0	73.3	85.0	88.3
E	33.1	58.5	78.3	89.2	95.0
F	32.7	59.5	80.0	88.3	95.0
G	36.7	58.0	85.6	87.8	96.7
H	53.2	70.0	82.1	88.8	95.0

Appendix Table IV-3. Continued.

	Incubation 1978				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	30.8	53.3	76.7	90.0	90.0
B	29.3	55.0	80.0	85.0	90.0
C	38.4	76.7	86.7	88.4	90.0
D	41.0	81.05	83.4	88.3	89.2
E	47.3	70.1	78.4	83.3	91.7
F	39.7	85.5	86.7	89.5	93.3
G	44.8	77.8	85.6	86.7	93.3
H	63.1	77.6	86.7	90.0	97.7

Appendix Table IV-3. Continued.

	Brood-rearing 1978				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	47.5	53.3	70.0	90.0	90.0
B	40.0	66.7	86.7	90.0	95.0
C	46.6	81.7	90.0	90.0	90.0
D	50.0	85.9	89.2	92.5	97.5
E	60.3	79.2	87.2	90.0	92.5
F	56.1	87.6	90.0	98.2	98.3
G	63.9	83.4	90.0	93.0	100.0
H	74.2	83.8	88.3	96.3	100.0

Appendix Table IV-3. Continued.

	Pre-laying 1979				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	6.7	12.5	29.2	46.7	43.3
B	4.1	9.5	22.8	30.7	41.5
C	10.9	29.8	36.8	45.5	65.0
D	24.0	47.0	62.7	67.1	74.4
E	27.7	44.4	60.6	71.4	76.5
F	26.6	38.8	49.0	58.2	85.6
G	17.3	55.0	62.7	83.3	93.3
H	41.3	56.5	68.1	78.8	87.5

Appendix Table IV-3. Continued.

Laying 1979					
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	9.2	34.2	53.3	63.3	76.7
B	6.7	17.9	63.4	63.4	68.4
C	15.4	24.2	38.4	55.4	61.6
D	26.0	40.2	63.6	69.2	81.7
E	38.7	50.4	61.7	77.5	79.5
F	27.9	39.5	45.8	71.6	81.7
G	22.8	34.9	54.7	73.6	83.1
H	46.9	63.7	72.0	82.0	90.0

Appendix Table IV-3. Continued.

Kind	Incubation 1979 Distance (meters) from which measurements were taken.				
	5	10	15	20	25
A	24.2	37.5	60.0	76.7	86.7
B	14.9	23.2	38.9	60.0	80.0
C	35.5	49.2	73.4	83.4	90.0
D	33.9	52.1	67.7	77.7	84.2
E	46.8	77.5	86.7	90.0	92.5
F	39.9	61.6	76.0	82.2	90.6
G	26.6	60.3	76.7	84.4	87.0
H	54.2	63.3	77.1	85.2	88.6

Appendix Table IV-3. Continued.

	Brood-rearing 1979				
	Distance (meters) from which measurements were taken.				
Kind	5	10	15	20	25
A	28.3	50.0	73.3	86.7	90.0
B	21.3	40.0	67.1	83.4	95.0
C	39.2	55.0	63.4	75.0	80.0
D	41.05	54.4	69.2	84.2	88.3
E	60.0	71.7	84.2	90.0	95.0
F	49.6	67.9	83.2	87.2	92.2
G	38.5	69.9	85.2	87.8	93.3
H	63.5	77.5	88.3	90.0	95.0

Appendix Table IV-4. Mean percent vertical coverage of vegetation measured from five distances from the vision board for each vegetation type on the BCPU. Vegetation types are ordered according to number of curlews observed in each type during formal censuses 1977 through 1979. N = 5 for every sample period.

Brood-rearing 1977

Vegetation Kind	Meters from vision board				
	5	10	15	20	25
12	6.7	10.8	14.2	15.8	19.2
1	4.1	10.2	18.0	17.4	25.3
28	8.2	10.3	10.3	17.3	21.0
15	20.0	60.0	76.7	83.3	86.7
14	15.0	18.3	53.0	76.7	83.3
27	14.2	50.8	60.0	73.3	100.0
22	10.8	42.5	53.3	100.0	100.0
21	16.0	19.7	23.4	37.2	83.3
7	21.7	73.0	80.0	83.3	86.7
9	25.8	76.7	83.8	83.3	90.0
3	5.0	5.0	25.8	100.0	100.0
24	47.5	76.7	90.0	90.0	100.0
6	27.5	40.8	90.0	100.0	100.0
23	5.0	14.2	15.8	47.5	53.3
16	8.2	12.9	20.9	60.0	86.7
8	5.0	20.8	34.2	53.3	63.3
2	14.2	31.7	47.5	47.5	56.7
4	15.8	40.8	56.7	76.7	90.0
10	39.2	90.0	90.0	100.0	100.0
26	32.5	73.3	90.0	90.0	90.0
20	40.0	80.0	90.0	86.7	90.0
19	12.5	40.8	73.3	86.7	90.0
5	11.7	43.3	90.0	90.0	90.0
17	47.2	86.7	90.0	100.0	100.0
13	6.7	21.7	43.3	95.0	100.0
11	8.3	43.3	53.3	60.0	76.7
18	34.2	63.3	76.7	80.0	90.0
25	34.2	53.3	100.0	100.0	100.0
29	42.5	50.8	83.3	86.7	90.0
30	80.0	80.0	90.0	86.7	100.0

Appendix Table IV-4. Continued.

Vegetation Kind	Pre-laying 1978				
	Meters from vision board				
	5	10	15	20	25
12	9.2	11.5	16.4	23.3	30.3
1	5.5	15.5	23.3	26.7	30.8
28	6.7	10.8	12.5	21.0	25.3
15	25.8	76.7	76.7	83.3	83.3
14	10.8	23.3	30.3	53.3	53.3
27	14.2	37.7	47.5	47.5	56.7
22	14.2	31.7	53.3	83.3	90.0
21	15.8	40.8	56.7	76.7	90.0
7	28.3	60.0	73.3	80.0	83.3
9	28.3	63.3	76.7	76.7	83.3
3	6.7	12.5	29.2	46.7	73.3
24	39.2	53.3	76.7	83.3	90.0
6	23.3	31.3	53.3	76.7	86.7
23	6.7	10.2	17.4	25.3	56.7
16	12.5	32.5	40.8	73.3	90.0
8	6.7	14.2	38.3	76.7	100.0
2	12.5	40.8	73.3	73.3	73.3
4	8.3	43.3	53.3	60.0	76.7
10	34.2	63.3	76.7	80.0	90.0
26	34.2	53.3	83.3	90.0	100.0
20	39.2	90.0	90.0	90.0	90.0
19	10.8	42.5	53.3	76.7	100.0
5	12.5	40.8	73.3	86.7	90.0
17	39.2	90.0	90.0	90.0	90.0
13	5.0	14.2	20.8	35.8	76.7
11	6.6	26.7	53.3	76.7	76.7
18	28.3	40.8	53 3	76.7	83.3
25	32.5	53.3	76.7	90.0	90.0
29	40.8	42.5	63.3	76.7	100.0
30	89.2	83.3	86.7	83.3	100.0

Appendix Table IV-4. Continued.

Laying 1978					
Vegetation Kind	Meters from vision board				
	5	10	15	20	25
12	14.2	21.7	50.8	53.3	66.7
1	12.5	20.3	38.8	43.3	56.3
20	21.4	33.3	50.3	63.3	63.3
15	38.8	90.0	90.0	90.0	90.0
14	14.2	50.8	63.3	76.6	83.3
27	26.7	53.3	76.7	76.7	83.3
22	22.5	40.8	63.3	76.7	90.0
21	25.8	53.3	63.3	76.7	90.0
7	39.2	76.7	90.0	90.0	90.0
9	40.8	76.7	90.0	90.0	100.0
3	12.5	38.8	83.3	90.0	100.0
24	44.2	73.3	90.0	90.0	90.0
6	35.0	45.0	63.3	86.7	90.0
23	8.3	57.5	76.7	90.0	90.0
16	26.7	63.3	76.7	83.3	90.0
8	11.7	28.8	76.7	90.0	100.0
2	22.5	57.5	83.3	86.7	90.0
4	14.2	63.3	76.7	90.0	90.0
10	47.2	86.7	90.0	90.0	100.0
26	40.0	80.0	90.0	90.0	100.0
20	47.5	53.3	90.0	90.0	100.0
19	22.5	40.8	76.7	83.3	90.0
5	22.5	56.7	83.3	90.0	100.0
17	47.5	70.0	90.0	90.0	90.0
13	8.3	57.5	76.7	90.0	90.0
11	8.2	24.2	76.7	90.0	100.0
18	35.0	45.0	63.0	86.7	90.0
25	53.0	90.0	90.0	90.0	100.0
29	84.5	80.8	86.7	83.3	90.0
30	87.5	83.3	90.0	90.0	100.0

Appendix Table IV-4. Continued.

Vegetation Kind	Incubation 1978				
	Meters from vision board				
	5	10	15	20	25
12	30.8	53.3	76.7	90.0	90.0
1	22.8	43.3	76.7	83.3	90.0
28	35.8	66.7	83.3	86.7	90.0
15	56.7	76.7	90.0	90.0	90.0
14	20.0	76.7	83.3	86.7	90.0
27	56.7	90.0	90.0	90.0	90.0
22	34.2	63.3	76.7	83.3	86.7
21	26.7	87.6	90.0	90.0	90.0
7	46.7	83.3	76.7	90.0	90.0
9	53.3	63.7	76.7	83.3	90.0
3	35.9	76.7	83.3	90.0	100.0
24	56.7	70.0	76.7	83.3	90.0
6	43.3	70.0	76.7	76.7	86.7
23	28.3	76.7	83.3	90.0	90.0
16	32.5	76.7	86.7	90.0	90.0
8	41.7	86.7	90.0	90.0	90.0
2	50.8	73.3	80.0	86.7	90.0
4	28.3	90.0	90.0	90.0	100.0
10	50.8	90.0	90.0	90.0	100.0
26	43.5	86.7	90.0	90.0	90.0
20	56.7	83.3	90.0	90.0	100.0
19	34.2	63.3	76.7	80.0	90.0
5	66.7	76.7	86.7	90.0	100.0
17	66.3	86.7	90.0	90.0	100.0
13	21.4	53.3	76.7	90.0	100.0
11	21.8	53.3	86.7	90.0	90.0
18	56.7	76.7	86.7	90.0	100.0
25	66.3	83.3	90.0	90.0	100.0
29	84.2	83.3	86.7	80.0	90.0
30	86.7	83.3	90.0	90.0	100.0

Appendix Table IV-4. Continued.

Vegetation Kind	Brood-rearing 1978				
	Meters from vision board				
	5	10	15	20	25
12	47.5	53.3	70.0	90.0	90.0
1	35.8	56.7	83.3	90.0	90.0
28	44.2	76.7	90.0	90.0	100.0
15	61.8	83.3	90.0	90.0	90.0
14	31.3	80.0	90.0	90.0	90.0
27	58.5	90.0	90.0	100.0	100.0
22	48.5	76.7	86.7	90.0	90.0
21	31.5	90.0	90.0	90.0	100.0
7	61.4	86.7	90.0	90.0	100.0
9	66.3	76.7	90.0	90.0	90.0
3	44.8	86.7	90.0	90.0	100.0
24	63.3	76.7	86.7	90.0	90.0
6	66.7	76.7	83.3	90.0	90.0
23	48.5	86.7	90.0	90.0	100.0
16	44.5	86.7	90.0	90.0	100.0
8	53.3	89.0	90.0	90.0	100.0
2	58.5	76.7	90.0	90.0	100.0
4	41.5	86.7	90.0	90.0	90.0
10	63.7	100.0	100.0	100.0	100.0
26	68.5	86.7	90.0	90.0	100.0
20	66.7	86.7	90.0	100.0	100.0
19	56.7	76.7	90.0	90.0	100.0
5	86.7	90.0	90.0	90.0	100.0
17	75.0	90.0	90.0	100.0	100.0
13	66.7	76.7	83.3	100.0	100.0
11	38.2	66.7	83.3	100.0	100.0
18	76.7	90.0	90.0	100.0	100.0
25	76.7	90.0	90.0	100.0	100.0
29	86.7	86.7	90.0	90.0	100.0
30	86.7	86.7	90.0	100.0	100.0

Appendix Table IV-4. Continued.

Pre-laying 1979					
Vegetation Kind	Meters from vision board				
	5	10	15	20	25
12	6.7	12.5	29.2	46.7	73.3
1	4.1	9.9	17.2	25.1	39.7
28	4.1	9.2	28.4	36.3	43.3
15	13.6	16.3	20.3	31.0	53.3
14	8.3	43.3	53.3	60.0	76.7
27	22.5	40.8	63.3	63.3	73.3
22	8.3	57.5	76.7	90.0	90.0
21	17.5	19.6	20.7	25.1	44.2
7	47.5	70.0	90.0	90.0	90.0
9	40.8	76.7	90.0	90.0	90.0
3	6.7	12.5	12.5	25.8	35.8
24	44.2	73.3	90.0	90.0	90.0
6	28.3	43.3	76.7	80.0	90.0
23	35.0	45.0	63.3	86.7	90.0
16	17.3	27.9	34.2	48.0	76.7
8	53.3	90.0	90.0	90.0	90.0
2	17.5	22.9	35.1	53.3	76.7
4	5.0	12.7	25.0	83.5	90.0
10	31.3	34.2	46.3	76.3	90.0
26	10.3	24.2	30.7	73.3	100.0
20	26.7	86.7	90.0	90.0	90.0
19	15.0	54.2	67.5	86.7	90.0
5	46.7	83.3	76.7	76.7	90.0
17	16.7	23.0	34.4	90.0	90.0
13	5.2	10.3	23.4	34.4	76.7
11	27.5	44.2	60.0	73.3	83.3
18	34.2	63.3	90.0	90.0	90.0
25	26.7	56.7	83.3	90.0	90.0
29	86.7	84.2	87.5	86.7	90.0
30	86.7	86.7	90.0	90.0	90.0

Appendix Table IV-4. Continued.

Vegetation Kind	Laying 1979				
	Meters from vision board				
	5	10	15	20	25
12	9.2	34.2	53.3	63.3	76.7
1	6.7	18.3	60.0	60.0	50.0
28	6.7	17.5	66.7	66.7	66.7
15	18.3	27.5	50.0	70.0	70.0
14	12.5	20.8	26.7	40.8	53.3
27	31.6	50.0	76.7	90.0	90.0
22	12.5	20.8	40.8	53.3	76.6
21	28.3	40.0	46.7	63.3	70.0
7	31.6	50.0	90.0	90.0	90.0
9	50.0	70.0	80.0	86.7	90.0
3	19.6	25.1	30.1	53.3	53.3
24	40.8	53.3	66.7	86.7	90.0
6	44.2	53.3	70.0	83.3	86.7
23	21.7	34.2	43.3	66.7	66.7
16	20.8	31.7	53.3	66.7	80.0
8	40.8	53.3	76.7	90.0	90.0
2	17.9	30.3	40.8	63.3	90.0
4	16.7	24.2	37.5	56.7	73.3
10	50.0	63.3	76.7	86.7	90.0
26	16.7	20.8	34.2	67.6	73.3
20	25.0	43.3	80.0	80.0	90.0
19	26.7	40.8	50.0	73.3	83.3
5	50.0	44.2	44.2	90.0	100.0
17	37.5	50.8	63.3	66.7	90.0
13	8.3	80.0	73.3	83.3	90.0
11	35.0	80.0	90.0	90.0	90.0
18	24.2	37.5	60.0	76.7	86.7
25	35.0	60.0	90.0	90.0	90.0
29	86.7	86.7	86.7	86.7	86.7
30	86.7	86.7	86.7	86.7	90.0

Appendix Table IV-4. Continued.

Vegetation Kind	Incubation 1979				
	Meters from vision board				
	5	10	15	20	25
12	24.2	37.5	60.0	76.7	86.7
1	15.9	19.4	37.5	53.3	76.7
28	13.9	27.0	40.3	66.7	83.3
15	46.7	66.7	90.0	90.0	90.0
14	24.2	31.7	56.7	76.7	90.0
27	43.3	53.3	70.0	86.7	90.0
22	14.2	31.7	47.5	47.5	56.7
21	30.8	46.7	63.3	86.7	90.0
7	47.5	76.7	90.0	90.0	100.0
9	47.2	86.7	90.0	100.0	100.0
3	35.8	63.3	76.7	80.0	90.0
24	47.5	70.0	90.0	90.0	90.0
6	56.7	90.0	90.0	90.0	90.0
23	34.2	63.3	76.7	80.0	90.0
16	34.2	53.3	90.0	90.0	100.0
8	57.5	76.7	83.3	90.0	100.0
2	22.5	40.8	63.3	73.3	63.3
4	34.5	48.7	53.3	76.7	90.0
10	56.7	86.7	90.0	90.0	100.0
26	20.0	83.3	90.0	90.0	90.0
20	27.5	44.2	60.0	73.3	83.3
19	32.5	53.3	80.0	90.0	90.0
5	60.0	73.3	83.3	90.0	90.0
17	49.2	80.0	86.7	90.0	90.0
13	25.8	40.8	63.3	76.7	86.7
11	43.3	70.0	76.7	76.7	76.7
18	24.2	35.0	60.0	80.0	86.7
25	50.8	73.3	80.0	86.7	90.0
29	82.5	83.3	86.0	90.0	90.0
30	86.7	84.2	80.0	83.3	86.7

Appendix Table IV-4. Continued.

Vegetation Kind	Brood-rearing 1979				
	Meters from vision board				
	5	10	15	20	25
12	28.3	50.0	73.3	86.7	90.0
1	20.8	46.7	86.7	90.0	100.0
28	21.7	33.3	47.5	76.7	90.0
15	50.0	70.0	80.0	86.7	90.0
14	28.3	40.0	46.7	63.3	70.0
27	50.0	63.3	76.7	86.7	90.0
22	26.7	40.8	50.0	73.3	83.3
21	40.8	53.3	76.7	90.0	90.0
7	46.7	60.0	73.3	86.7	90.0
9	66.7	83.3	90.0	90.0	90.0
3	50.0	70.0	86.7	90.0	100.0
24	56.7	56.7	76.7	90.0	100.0
6	66.7	76.7	83.3	90.0	90.0
23	46.7	60.0	83.3	90.0	90.0
16	56.7	63.3	90.0	90.0	100.0
8	66.7	90.0	90.0	90.0	90.0
2	26.7	40.8	50.0	73.3	83.3
4	47.5	76.7	90.0	90.0	90.0
10	53.3	76.7	90.0	90.0	100.0
26	35.3	53.3	76.7	83.3	90.0
20	35.8	73.3	90.0	90.0	90.0
19	45.0	83.3	90.0	90.0	100.0
5	76.7	83.3	90.0	90.0	100.0
17	53.3	76.7	90.0	90.0	90.0
13	46.7	76.7	90.0	90.0	96.0
11	53.3	76.7	83.3	90.0	90.0
18	39.5	53.3	83.3	90.0	100.0
25	66.7	83.3	90.0	90.0	100.0
29	85.0	83.3	90.0	90.0	90.0
30	86.7	86.7	90.0	90.0	90.0

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